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THE SEA BOTTOM—ITS PHYSICAL CONDITIONS AND ITS FAUNA.*

IT is hard to realize the fact that, up to a comparatively recent date, nearly three-fifths of the actual solid surface of the earth was absolutely a 'terra incognita,' a region as unknown as the poles, and as full of mystery as the center of the earth. Yet, if it be true that the sea covers nearly three-fifths of the surface of the earth, it is also true that its bottom, which is the actual solid surface of the globe, was, up to the middle of the century just ended, absolutely unexplored, excepting a very narrow strip around the edges.

For the purpose of our study this evening, we may define the deep sea as all that is deep enough to exclude sunlight and vegetable life in appreciable quantities from the bottom. We may safely assume that this limit is at a depth of about 150 fathoms. Sensitive photographic plates are said to be unaffected beyond the depth of about 125 fathoms clear water.

It thus becomes apparent that we shall have to include as deep sea almost all the area covered by the oceans of the world, there being but an inconsiderable strip around the edges that is within the 150-fathom line. The average depth is very

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much greater than that. Indeed, we now know that more than one half of the actual surface of the globe is over two miles beneath the surface of the water, and that about seven million square miles are buried under more than 3,000 fathoms of ocean.

Still greater depths are by no means uncommon. The *Challenger* sounded at a depth of 4,561 fathoms in the North Atlantic, and Uncle Samuel, not to be outdone by his British brother, very recently found a depth of 5,200 fathoms near the lately acquired Island of Guam. This is, so far as we know, the deepest abyss of the ocean, being 31,200 feet, or nearly six miles. Into such a depth the highest terrestrial mountain could be plunged without any resultant peril to navigation, as there would still be some 2,000 feet above the highest crest.

As already indicated, this vast realm of darkness was unexplored previous to about the middle of the nineteenth century. The pioneer explorer of the sea bottom was a Norwegian zoologist, Michael Sars. Then followed several expeditions under the patronage of the British Government, culminating in the *Challenger* voyage, the results of which stand to-day as a peerless example of a wise and liberal policy in the encouragement of scientific research.

The United States has come well to the front in deep-sea investigation, and now owns the best equipped vessel for this work in the world. I refer to the *Albatross*, of which we shall hear more later. Americans may well take pride in remembering that the oceanic basins near our eastern and southern coasts are more thoroughly explored than any other parts of the sea bottom.

Investigations of this nature have been attended with almost insuperable difficulties, necessitating the devising of a number of entirely novel instruments and machines for this particular work. Several of the most successful of these were invented by American naval officers, of whom Captain Sigsbee, of the ill-fated *Maine*, has been the most prominent. Our knowledge of the sea bottom has been gained mainly by the use of the following appliances :

1. The *sounding machine*. To drop a weight attached to a line to the bottom of the sea would seem to be as simple a proposition as could well be devised. As a matter of fact, however, its successful accomplishment has taxed the inventive genius of the most accomplished engineers. Sigsbee's sounding machine, with detachable weight and piano-wire line has proved the best device for obtaining accurate soundings and adequate samples of the bottom. This and the other instruments about to be mentioned will be illustrated and briefly explained later.

2. The *thermometer*. Temperature observations have been of the utmost importance in determining the physical conditions of the deep sea, and various kinds of thermometers have been devised to withstand the enormous pressure and register the maximum and minimum heat. Not infrequently these expensive instruments have been brought to the surface with their bulbs crushed to powder by the terrific pressure of the abyss.

3. The *water bottle*. Not only must depth and temperature be ascertained, but the actual composition and condensation of the water must be found by means of samples that can be secured free from admixture with sea water of other depths. Here also the genius of Captain Sigsbee was equal to the emergency, and the 'Sigsbee water bottle' has proved itself a convenient and efficient instrument, being so constructed that it will take a sample of water at any given depth and then automatically seal itself and remain hermetically closed until opened by hand.

4. The *dredge*, for scraping over the bottom and securing specimens of the animal life of the deep.

5. The *trawl*. A large bag-like net, useful on soft bottoms, over which it will pass without digging into the soil. It has a larger mouth and greater capacity than the dredge.

6. The *tangle-bar*, to sweep over rocky bottoms on which the other instruments would foul and often be lost. It is in effect a series of long swabs that will entangle in its hempen fibers almost anything from coral rock to fishes. It is probably the most effective all-around instrument for general work, and the least likely to fail or be lost. We found it invaluable in West Indian waters of moderate depths.

With these six instruments, then, the sea bottom has been sounded, its temperature taken, samples of both water and bottom secured and specimens of its animal life brought to light, both figuratively and literally. As yet this vast territory has been but scratched here and there. We can speak with confidence, however, concerning the general physical conditions, and we are acquainted with thousands of the strange and bizarre creatures that constitute its fauna.

Regarding the physical features of this under world, the following points are worth consideration :

The temperature is uniformly low, probably below 40°, except in enclosed seas in tropical regions such as the Red Sea. In many places the temperature is actually below the freezing point of fresh water. I well remember the surprise felt by the members of a dredging party one excessively hot day off Havana, indeed within sight of the now famous Morro Castle, when they plunged their hands in a mass of mud brought up in the dredge and found it so cold as to make them fairly ache. Of course the cold water reaches the surface in high latitudes, but it covers the entire floor of the ocean at depths over 150 fathoms. This practical uniformity of temperature over the entire submarine surface of the globe plays an important part in the well-known wide distribution of deep-sea species.

The general impression that high temperature is more favorable than a low one for the best development of animal life is certainly not true of marine animals in general, whatever may be the facts concerning some special groups. If other conditions are favorable, a luxuriant fauna will be developed in any temperature short of the freezing point of salt water. But a *change* of temperature, if a sudden one, is sometimes the cause of oceanic tragedies of frightful extent, a fact illustrated by the following example :

The tile-fish is a deep-water species, living upon the bottom on what is known as the Gulf Stream slope, off the New England coast. Here the water is normally comparatively warm, coming as it does from the superheated region of the Gulf of Mexico.

During a series of unusually severe gales in the summer of 1882 this mass of water was pushed aside, as it were, and replaced by the colder water. As a result, millions and millions of these fish were killed, and their dead bodies literally covered the surface of the sea for hundreds of square miles. So great was the slaughter that for years it was feared that the tile-fish were exterminated. Fortunately, however, the region has been recolonized, probably from the south, and numerous tile-fish have been taken during the past two seasons.

Probably the most remarkable of the conditions of deep-sea life is the enormous pressure, which varies of course with the depth. At the average depth (2,000 fathoms) the pressure is about two tons to the square inch of surface, and at 4,000 fathoms each square inch of surface is subject to a pressure of about four tons. This fact led the earlier physicists to maintain that or-

ganic life was impossible in the great depths. It has been proved, however, that animals of all classes, except the higher vertebrates, have been dredged from even the deepest abysses of the ocean.

The great pressure to which they have been subjected has a curious effect on the deep-sea fishes when they are brought to the surface. Under these circumstances, being released from the accustomed pressure, they fall to pieces, as it were. The eyes bulge out, the swim-bladder protrudes from the mouth, the scales fall off and the flesh comes off in patches, the tissues being remarkably loose. Now these fishes, disreputable as they appear when brought to the surface, were doubtless respectable enough in their proper habitat, and, like some other creatures, become loose and far from correct in appearance when away from home, simply because the pressure is less.

In the depths they are doubtless no more conscious of the pressure of four or five tons to the inch than we are of the fifteen pounds of atmospheric pressure under which we live and move and have our being.

Owing to the incompressible nature of water it does not differ appreciably in density at different depths, and any object that will sink at the surface will continue to sink until the bottom is reached, however deep that may be.

The presence of oxygen is of course of vital import to animal life in the deep sea as elsewhere, and it was long deemed impossible that any considerable quantity of oxygen could exist at great depths. It has been found, however, that there is no lack of this vital element either near the surface or in the deepest soundings. Sir Wyville Thomson, the naturalist in charge of the *Challenger*, made a very careful study of oceanic currents and found that the cold water of the polar regions, charged with oxygen derived from the superincumbent atmosphere, creeps along the bottom towards the equator from both poles, thus carrying oxygenated water over the vast area of sea bottom throughout the oceanic floor of the world. It also appears that the general trend of the surface water is toward the poles. This great scheme of circulation involves the general rise of the cold, deep water of the equatorial regions toward the surface, where it receives a fresh supply of heat and oxygen, carries much of the heat to northern regions and, after giving it off, returns southward again in the form of oxygen-bearing undercurrents. To my mind there are few terrestrial phenomena more impressive than this majestic cosmic current with circulation slow and sure, carrying with it the tremendous potency of life to and throughout the uttermost depths of the sea. Were it not for this world circulation, it is altogether probable that the ocean would in time become too foul to sustain animal life, at least in its higher manifestations, and the sea, the mother of life, would itself be dead.

The condition of the physical environment of the life of the ocean depths that strikes one as the most forbidding is the practical absence of sunlight from the enormous area included in the deep sea. As already stated, actual experiment has shown that photographic plates are not affected at a depth of over 125 fathoms in clear water, and light, which can not be detected by the exceedingly delicate eye of the camera, is surely invisible to any organ of vision constructed on the same general plan as the human eye. There is practical agreement among all the authorities, save one, that I have been able to consult that the rays of the sun do not penetrate perceptibly below the 200-fathom line at the farthest. Professor Verrill is the exception referred to, and he has advanced the theory that a pale green light penetrates even to the deepest waters. He thinks that all the other colors of the spec-

trum are removed from the sun's rays by absorption, leaving the green rays only. He comes to this conclusion from a study of the colors of the animals of the deep sea, which demonstrate, in his opinion, the presence of light of some kind. He apparently assumes that this light comes from the sun, and resorts to the explanation just referred to to prove its presence in the oceanic depths.

We shall see presently, I hope, that it is not necessary to assume the presence of sunlight at the sea bottom in order to meet the demands for light revealed by a study of the coloration of its inhabitants.

The bottom waters, then, are almost freezing cold, subject to tremendous pressure, moved by slow currents creeping from pole to equator, supplied with sufficient oxygen to sustain animal life, and devoid of sunlight. Could a more uncomfortable and altogether forbidding habitat be conceived of for an animal population? Certainly not, from our standpoint. But it must be remembered that we are neither fishes, nor mollusks, nor jelly-fishes; and that everything depends upon being used to environment. A practical application of this fact would result in the saving of a lot of otherwise wasted sympathy in human as well as zoological affairs.

Let us now turn our attention briefly to the topography of the sea bottom. It may be said, in general, that there are few abrupt changes of level; that the ascents and descents are gradual, and that there are few areas which, if laid bare, would present anything like the broken contours of a mountainous region. In areas adjacent to continents and archipelagoes the topography is often considerably broken, but away from the land masses the sea bottom is, ordinarily, as level as a western prairie. Few, if any, bare rocks are to be found, except where recent submarine volcanic explosions have torn up the subjacent strata, or the cooling lava has encrusted the bottom. Practically the entire sea bottom is covered to an unknown depth by a soil that varies with the depth in a definitely determinate manner. This soil, like that of the upper world, is organic in its origin, being composed in large proportion of the remains of a few species of very widespread forms, individually minute, but collectively of stupendous bulk. These animals belong almost exclusively to the Protozoa, or one-celled forms, and largely to the class Rhizopoda. They are of immeasurable importance from a biological standpoint, furnishing, as they do, the food basis for all marine life. As a type of these organisms *Globigerina bulloides* stands forth preeminent, a form of exquisite beauty of structure, being like a series of minute chalky spheres, exquisitely sculptured, from which radiate many and almost infinitely slender and delicate spicules which serve to support the living animal on the water, which, in places, is rendered of a reddish color by the hosts of these Rhizopods. It has fallen to the lot of but few naturalists to examine these creatures in a living and perfect state, as the slightest touch will rob them of their beautiful spicules and cause the living protoplasm to retreat within the hollows of the spheres. Minute and fragile as they are, the skeletons of these animals, and of others equally small, cover at the present time many millions of miles of the sea bottom, and in times past were the main element in building up the mighty chalk deposits of the world.

If we were to run a line of soundings from the continent of North America eastward to the mid-Atlantic, we should find that the bottom could be easily divided into three regions on the basis of the soil, as I have termed it, covering everywhere the actual rocks. For the first few miles the bottom would be covered with débris of many kinds from the adjacent land.

Rocks and gravel and sand, together with mud and silt, if near the mouth of a river, would succeed each other. The surface might be broken into rocky pinnacles and caverns, water-worn in fantastic shapes in the region of a rocky coast; or, if the coast be low and sandy, there might be a perfectly even and gradual slope from the shore to a depth of 150 or perhaps 200 fathoms.

This slope, covered with continental débris, is known as the 'continental slope,' and is very apt to be more uneven and broken in its topography and to support a more luxuriant fauna than any other part of the sea bottom. Beyond the continental slope the descent becomes more abrupt, leading down to a depth of 1,500 fathoms or more.

The bottom samples will now take on a distinctly different character, being composed of a grayish mud. If a little of this is examined under a microscope, it will be found to be made up of countless millions of the tests of *Globigerina* and other unicellular animals. Not a single thimbleful of this mud is devoid of its hosts of skeletons. This wet and slimy bottom soil is known the world over as '*Globigerina ooze*,' and it covers the ocean floor for many millions of square miles.

In a line of dredgings made by the *Challenger* from Teneriffe to Sombrero, taking in the widest part of the Atlantic, about 710 miles were found to be covered with *Globigerina ooze*, which was found in characteristic form from a depth of 1,525 to one of 2,220 fathoms. Beyond the latter depth the bottom was of a distinctly different character, changing to an extremely fine-grained reddish-brown mud, oily to the feel. It is so finely divided that it takes many hours to settle when mixed in a glass of water. This is known among oceanographers as 'red clay,' and is supposed to be derived almost exclusively from two widely different sources:

First: The residue of the innumerable hosts of pelagic animals remaining after their calcareous skeletons have been dissolved in sea water.

Second: Pumice and volcanic dust, either from submarine upheavals or from the atmosphere. From either or both of these sources the accumulation of the red clay must have been almost infinitely slow, taking perhaps millions of years to deposit a few inches in thickness on the ocean floor. This sort of bottom deposit is of much greater extent than either of the others, and is supposed to cover about one-half of the sea bottom, an area greater than the total land surface of the globe.

It can easily be conceived that no stretch of the land surface can compare in dreary monotony with those awful solitudes of the *Globigerina ooze* and the red clay. Even if illuminated by the sun's rays, they would be forbidding and dreary beyond compare.

Resting immediately upon the bottom already described is a layer of unknown depth of a flocculent material that is of incalculable importance in our discussion. When first discovered this substance, owing to its strange movements in alcohol, was supposed to be alive, and was described by Huxley under the name of *Bathybius*, and considered as a sort of primordial organism from which the entire life of the globe may have originated. *Bathybius*, however, was doomed to be regarded as one of the colossal jokes of science, and a thorn in the flesh of its describers.

But, after all, it is now thought that the much-derided *Bathybius* is fully as important as claimed by Huxley, but in another way. It is not alive, to be sure, but still it is organic, consisting of the partially decomposed remains of the pelagic animals, such as *Globigerina* and other forms already referred to. These have died near the surface, and have gradually but surely found their way to the bottom, where they remain

partially suspended in a layer of soup-like consistency and character. *Bathybius*, then, is now no longer known as *Bathybius*, but as '*bottom broth*,' an exceedingly suggestive term, and it is supposed to be the inexhaustible supply of nourishment, the basal food store-house of the innumerable creatures that live and move, or simply live without movement, at or near the bottom of the sea, the simplest and most helpless of which have but to open their mouths, if mouths they have, and suck in bottom broth as the infant does pap. If Old Ocean is really, as so often asserted, the mother of terrestrial life, then bottom broth can truly be regarded as a sort of mother's milk, for the nourishing of her weak and helpless offspring.

Having discussed the physical conditions under which the animals of the deep sea exist, let us now turn our attention to the animals themselves.

Personally, I may say that nothing regarding the animals dredged from deep water has impressed me more than their colors. It seems an unquestionable fact that they live in practical darkness, and one naturally expects them to be colorless.

Now we know of a considerable number of animal forms that certainly do live in utter darkness in the subterranean waters of extensive caves, such as Mammoth or Wyandotte Caves. These animals have been very carefully studied, especially by my friend Dr. Eigenmann, of Indiana University, who tells me that true cave species are always practically blind and colorless. But the animals brought up from the deep waters of the ocean are often very brightly and conspicuously colored.

The question at once arises: What is the significance of these colors? Are they merely fortuitous, or have they a meaning that can be deciphered, giving a clue that may lead to a further understanding of the mysterious realm beneath the waters? It is my purpose this evening to attempt to answer these questions, but before doing so let us examine briefly the main facts regarding the colors of abyssal animals. We will call as witnesses some of the naturalists of the widest experience in the science of thalossography, and supplement this evidence by facts of personal observation.

Professor Mosely, of the *Challenger* staff, says: "Peculiar coloring matter giving absorption spectra has now been found to exist in all the seven groups of the animal kingdom. The Echinodermata and Cœlenterata appear to be the groups which are most prolific in such coloring matter. Pentocrinin and antodonin seem to be diffused in immense quantities throughout the tissues of the crinoids in which they occur and the Echinoderms generally seem to be characterized by the presence of evenly diffused and abundant and readily soluble pigments." Again, he says: "The same coloring matters exist in the deep-sea animals which are found in shallow water forms."

Alexander Agassiz, than whom no living man has had more experience in deep sea work, says: "There are many vividly colored bathyssal animals belonging to all the classes of the animal kingdom and possessing nearly all the hues found in living types in littoral waters. * * * There is apparently in the abysses of the sea the same adaptation to the surroundings as upon the littoral zone. We meet with highly colored ophiurans within masses of sponges themselves brilliantly colored at a depth of more than 150 fathoms. * * * While we recognize the predominance of tints of white, pink, red, scarlet, orange, violet, purple, green, yellow and allied colors in deep water types, the variety of coloring among them is quite as striking as that of better known marine animals. * * * There is as great a diversity in color in the reds, oranges, greens, yellows, and

scarlets of the deep-water starfishes and ophiurans, as there is in those of our rocky and sandy shores. * * * Among the abyssal invertebrates living in commensalism the adaptation to surroundings is fully as marked as in shallow waters. I may mention especially the many species of ophiurans attached to variously colored gorgonians, branching corals and stems of *Pentacrinus* scarcely to be distinguished from the part to which they cling, so completely has their pattern of coloration become identified with it. There is a similar agreement in coloration in annelids when commensal upon starfishes, mollusks, actiniæ or sponges, and with Crustacea and actiniæ parasitic upon gorgonians, corals, or mollusks. The number of crustaceans * * * colored a brilliant scarlet is quite large."

Professor Verrill, of Yale University, in his report on the Ophiurans, collected by the Bahama expedition from the University of Iowa, repeatedly calls attention to the agreement in color between these animals and the forms upon which they grow.

My own observations fully confirm those of the naturalists just quoted. Among the crustaceans were many species colored a bright scarlet, and one was an intense blue. The echinoderms were particularly striking in their coloration. Yellow and purple Comatulæ abounded in deep water near Havana. Serpent-stars were brown, white, yellow, red, purple and deep violet. A basket-fish, colored chocolate-brown and vivid orange, was abundant off the Florida Keys. There were sea urchins with crimson and white spines; another particularly gorgeous one had a test with alternating zones of chocolate and orange, and spines barred with carmine and white. The cœlenterates told the same story, but it is unnecessary to multiply further the evidence. Enough has been given for our purpose, which was to demonstrate the existence of bright colors in considerable quantities in the deep waters of the ocean, and we feel justified in making the following general statements regarding these colors:

1. The colors are often as brilliant as in shallow water.

2. The reds, orange, yellows, violet, purple, green and white predominate.

3. The colors when present are usually in solid masses in striking contrast, or else the whole animal is brilliantly colored. Fine patterns are very scarce, and nature seems to have used a large brush in adorning her children of the depths.

Now let us return to our question: What is the significance of these brilliant and varied colors?

I must confess to being a Darwinian of the strict constructionist school, and believe fully in the doctrine that no animal possesses any character, including color, that is not of use to the species to which it belongs, or has not been of use to the ancestors of that species. It is my conviction that if we knew all the circumstances surrounding the past history and present life of any animal, we could explain on the score of utility every character, using the word in the zoological sense, possessed by that species. And it is my purpose to use the coloration of deep-sea animals to illustrate this law.

In my opinion, the presence of all these colors can mean but one thing, and that is that there is light even in the deepest depths of the ocean. Or, to state the matter in another way, if we can prove the presence of light in considerable quantity at the bottom of the sea, the colors of its inhabitants become entirely explicable. We can then explain them as we do the colors of the animals of shallow waters, regarding the colors as protective, aggressive, alluring, attractive, directive, and so forth, as the case may be.

There is another line of evidence tending to prove the presence of light at the sea bottom, and this is the fact that most of the vertebrates inhabiting the depths have functional eyes, often more highly developed than in shallow water, and only exceptionally are the eyes aborted or absent. Dr. Alexander Agassiz has the following to say on this point:

"We should not forget, on the one hand, that blind Crustacea and other marine invertebrates without eyes, or with rudimentary organs of vision, have been dredged from a depth of less than 200 fathoms, and, on the other, that the fauna as a whole is not blind, as in caves, but that by far the majority of animals living at a depth of about 2,000 fathoms have eyes either like their allies of shallow water, or else rudimentary or sometimes very large, as in the huge eyes developed out of all proportion in some of the abyssal crustaceans and fishes."

And Professor Verrill says: "That light of some kind and in considerable amount actually exists at depths below 2,000 fathoms may be regarded as certain. This is shown by the presence of well-developed eyes in most of the fishes, all of the cephalopods, most of the decapod crustacea, and in some species of other groups. In many of these animals the eyes are relatively larger than in the allied shallow-water species."

In view of the almost uniformly blind condition of cave animals on the one hand, and of the well-tested Darwinian doctrine that useless structures, unless rudimentary, do not exist, on the other, I think we are justified in saying that a study of the coloration of the deep-sea animals, in connection with the general presence of functional eyes, is reasonable proof that light in appreciable quantities exists even at the greatest oceanic depths.

This being granted, we naturally turn to a consideration of the question: What is the nature of this abyssal light?

As already intimated, it is incredible that sunlight could penetrate in appreciable quantities to any such depth as 2,000 fathoms or over, or even to one-tenth of that depth, notwithstanding the theory advanced by Verrill, who seems to consider the presence of sunlight necessary to explain the facts of coloration. I think we are safe in assuming with Agassiz that at 200 fathoms the light from the sun is possibly that of a brilliant starlight night, and we are also justified in concluding that coloration would be useless in such a light. Did you ever notice how little of color can be seen even in the clearest moonlight night?

Sunlight being out of the question, is there evidence of any other light that would satisfy the conditions of coloration and organs of vision already referred to?

I have, on other occasions, sought to collect the evidence of the existence of abyssal light, and to determine its nature and function in the life economy of the deep sea. These efforts resulted in the belief that the light sought for is a phosphorescent light, and that it is adequate to explain the phenomena already discussed in connection with the colors of deep-sea animals.

This idea has been suggested before by several writers, notably by Andrew Murray, of the *Challenger*, but it has heretofore been only a suggestion which no one has taken the pains to seriously investigate. It will be of interest, therefore, to consider the extent to which phosphorescent life is characteristic of the deep sea.

For the purposes of the discussion we will divide the animals of the sea bottom into two classes, the free swimming and the fixed forms.

Considering the free swimming forms first, we find among the fishes several allied to *Lophius* and *Antennarius*, which are provided with a bait said to be luminous, which serves to attract the prey. Others are luminous along the lateral line in defi-

nite spots. The utility in this case is not certainly known, but two suggestions may be made, one to the effect that the light attracts the mate and thus serves the purpose of attractive coloration; the other that it attracts the prey and serves the purpose of alluring coloration.

A very large number of crustaceans are highly phosphorescent. Many of these have large eyes and are particularly active in movement and voracious in appetite. They feed on minute organisms for the most part, and it can hardly be doubted that they often use their phosphorescent powers for the purpose of illuminating their surroundings and revealing their prey. Here again it is probable that the strangely attractive power of light serves a definite purpose in the life economy of the animal.

Among the mollusca we have few instances, so far as I know, of phosphorescent organs. At the Detroit meeting of the American Association for the Advancement of Science, Professor William E. Hoyle, of England, read an exceedingly interesting paper on certain organs possessed by cephalopods secured by the *Challenger*. These organs were regarded as phosphorescent by Professor Hoyle, who described a highly specialized apparatus designed to reflect light from the phosphorescent bodies downward to the bottom over which the animal passed. In this case it appears that there is not only a light, but also a reflector, an efficient bull's-eye lantern for use in hunting through the abyssal darkness. Among the worms are many forms possessing a high degree of light-emitting power, which may be either attractive, alluring or directive in function, and thus of direct advantage to its possessors.

Most of the echinoderms, although not truly fixed, are not capable of rapid locomotion, and we are, therefore, not surprised to find few references to phosphorescence in connection with them. Perhaps the most active of this group are the serpent stars, and it is interesting that the only account that I find of phosphorescence in the echinoderms is Agassiz's description of a serpent star, which he says 'is exceedingly phosphorescent, emitting at the joints along the whole length of its arm a bright bluish-green light.'

Coming to the cœlenterates, we find many notable phosphorescent organisms. The ctenophores and medusæ comprise the greater part of the free swimming members of this subkingdom, and it is among these that we encounter amazing displays of the living light. The most brilliant exhibition of phosphorescence that I have seen was caused by immense numbers of ctenophores in Bahia Honda, Cuba. The animals kept in a compact body, producing a maze of intertwining circles of vivid light. The phosphorescence may help to keep them together, and thus serve the purpose of directive coloration among vertebrates and insects. This same explanation may apply to many of the phosphorescent medusæ. In the subtropical Atlantic hundreds of square miles of the surface are thickly strewn with a medusa, *Linerges mercurius*, which glows like a living coal at night.

In general, it may be said that phosphorescence is found abundantly in free swimming marine animals, and serves the same purpose as protective, aggressive and alluring coloration, and at the same time, in many cases, aids in securing prey by illuminating its retreat.

We come, now, to a consideration of the phosphorescence of the fixed animals of the deep sea and its uses. Most of the light-emitting organisms of this group belong to the subkingdom cœlenterata. The sea-pens are mentioned by several writers as being especially brilliant in their flashes of light. The gorgonians, or flexible corals, are often phosphorescent, and Agassiz says: "Species living beyond 100 fathoms may

dwell in total darkness and be illuminated at times merely by the movements of abyssal fishes through the forests of phosphorescent alcyonarians."

Many authors have noted the light-emitting powers of numerous hydroids. These occur in great quantities over certain areas of the sea bottom, and must add considerably to the sum total of deep-sea light.

It may, I think, be said that in general the fixed marine forms are not behind their free swimming allies in either the equality or the quantity of their light-emitting powers. The question now arises, of what value is the phosphorescence of fixed forms to its possessors? They have no eyes, and therefore can not be guided to their food by the light, neither can it aid them in finding mates nor in revealing the presence of enemies. Perhaps the most generally accepted explanation is that given by Professor Verrill, who says that the phosphorescence protects its possessors. Most cœlenterates, he says, are possessed of nematocysts or nettling cells, and the phosphorescence may serve to give notice to predaceous fishes that feed largely on hydroids, etc., that these nettling cells are present, and thus induce them to seek other provender. It is somewhat unfortunate for this argument that few if any of the cœlenterates that are remarkable for their phosphorescence possess nettling cells that are likely to be regarded by a hungry fish as at all formidable.

Another explanation is, however, possible. The food of the cœlenterates consists mainly of either crustacea of the smaller sorts, their embryos, protozoans, or unicellular plants. Now most of the crustacea have functional eyes, and it has been repeatedly demonstrated that they are attracted by light, both artifical and natural. Crustacean embryos usually have eyes that are proportionally very large. In many cases these too are attracted by light, and it is reasonable to suppose that they are attracted by phosphorescent light. If this is true, the light emitted by the fixed cœlenterates would cause the small crustaceans, and more surely their embryos, to congregrate near the illuminated areas and thus be captured. The process would be analogous, perhaps, to what is known as the effect of alluring coloration among insects and birds. The phosphorescence would thus be of direct utility to the fixed cœlenterates in securing food.

The application of this idea may be still further extended to include the attraction of Protozoa and even diatoms, both of which groups contain many species that are strongly attracted by light, which appears to act as a direct stimulus to both unicellular animals and plants by virtue of its well-known effect upon protoplasm itself.

One other fact, bearing directly on our discussion, that impresses itself strongly upon every one who has had actual experience in deep-water dredging, is the very uneven distribution of life over the sea bottom. In other words, the distribution is 'spotted.' A haul over certain areas will result in a dredge full of a profusion of animal forms, while the immediately adjacent bottom, although of apparently identical nature, will yield practically nothing. Our party repeatedly observed this while dredging on the Pourtales Plateau. It seemed as if species were distributed in densely crowded colonies of very limited areas. Sometimes one particular species seems to have fairly carpeted the bottom, and in other localities a great assemblage of species would be secured at a single haul, showing a profusion of life, perhaps greater than can be found on a similar area either in shallow water or on land. Again the tangles would come up with nothing but sand and bottom débris.

It seems, then, that we are justified in

concluding that the sea bottom is, for the most part, utterly dark, but that there are scattered areas, often of considerable, extent where animal life is aggregated in masses, and where the phosphorescent light is of sufficient quantity to render the colors, laid on as we have seen in broad patterns, visible to animals with functional eyes. These colors would then be of the same utility to their possessors as in the upper world, and act as protective, aggressive, directive, attractive and alluring agencies. We are further justified in maintaining that phosphorescence is in all cases of direct utility to its possessors, and that in the fixed eyeless forms it serves to attract food, and perhaps in some cases to warn enemies of the presence of the irritating nettling cells.

As a sort of compensation for the feebleness of the phosphorescent light, and for its absence over vast areas, many animals, especially fishes and crustaceans, are furnished with very large eyes, or with organs which serve as lanterns, or with enormous mouths and stomachs to make the most of a very occasional square meal, or with greatly elongated feelers or tactile organs. Others still are provided with a luminous bait to attract the prey.

The main thing that I would impress upon you this evening is the fact that we have a right to expect to find utility for every character, not rudimentary, possessed by animals, a utility not necessarily to the individual, but certainly to the species. And I would protest most vigorously against the vain and impotent conclusion that anything is useless simply because we have been too ignorant or too indolent to find its function. I have small patience with a statement such as the following taken from a recent writer on animal coloration: "The inevitable conclusion, therefore, from these facts appears to be that the brilliant and varied colorations of deep-sea animals are totally devoid of meaning; they can not be of advantage for protective purposes or as warning colors, for the simple and sufficient reason that they are invisible."

This sort of thing is deeply injurious to science, because it is a helpless surrender of one of the most powerful of all incentives to research. If we can loll back in our easy chairs and declare that natural phenomena of widespread occurrence are meaningless, or, what amounts to the same thing, that Nature is guilty of a lot of vapid nonsense, we have indeed sold our scientific birthright for a mess of exceedingly thin pottage, and have stultified ourselves in the eyes of the thinking world.*

C. C. Nutting.
State University of Iowa.

REMINISCENT REMARKS ON THE TOP.

Some time ago, I wrote a short article in this journal,† in which among other things I endeavored to give an intelligible explanation of all that, from an elementary point of view, is interesting in the dynamics of the top. The treatment of this famous and ubiquitous apparatus in all text-books known to me is too sketchy and, didactically considered, useless. In my judgment this is a real gap and well worth filling. But my friends have so frequently and even quite recently taken me to task for my explanation, that I feel bound to reassert its correctness here.

Everybody will agree that up to the second order of approximation, and a vigorously spinning top or gyroscope, in which $\dot{\theta}$ is the polar velocity and φ and ψ the parameters of azimuth and altitude,

* Most of the facts and sometimes whole paragraphs concerning the coloration of deep-sea animals and phosphorescence, have been taken from the following papers by the author: 'The Color of Deep Sea Animals,' *Proc. Iowa Acad. of Sci.*, Vol. VI.; 'The Utility of Phosphorescence in Deep Sea Animals,' *Am. Nat.*, Oct., 1899.

† Science, V., pp. 171–5.

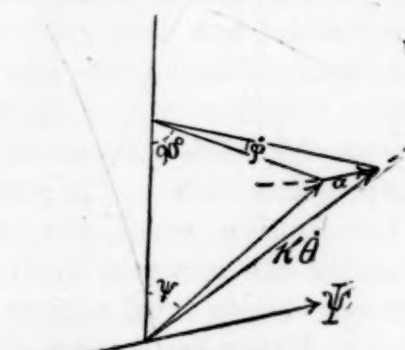
$$\Psi = K\dot{\theta} \sin \psi \cdot \dot{\varphi}, \qquad (1)$$

$$\Phi = -K\dot{\theta} \sin \psi \cdot \dot{\psi}, \qquad (2)$$

will express the motion. Here Ψ and Φ are the torques around the horizontal and vertical axes, respectively, and K the polar moment of inertia ; friction is disregarded.* Hence $\ddot{\theta}$, $\dot{\varphi}$, $\dot{\psi}$, are of the first order of small quantities, $\ddot{\varphi}$ and $\ddot{\psi}$ of the second order.

The point is now to show that these equations are reproduced in my geometrical constructions relative to the common theorem of the equivalence of torque, and the change of angular momentum per second around any particular direction.

I. *Torque* (Ψ) *around the horizontal axis only. Precession.*—Take any two positions of the top axis, a second of time in position apart. Lay off the angular momenta $K\dot{\theta}$,



Ψ, only.

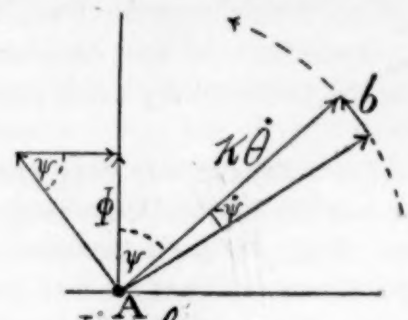
along these axes. They are equal by the premises. Hence the horizontal arc, a, is the rate of change of angular momentum due to the torque Ψ around the parallel axis shown. In the second of time stated, the angle of azimuth has changed by $\dot{\varphi}$, as shown in the figure. Therefore, the arc

$$a = K\dot{\theta} \sin \psi \cdot \dot{\varphi},$$

and hence

$$\Psi = K\dot{\theta} \sin \psi \cdot \dot{\varphi},$$

II. *Torque Φ around the vertical axis only.*—This requires gyroscopic mounting. Let the horizontal axis be seen end on at A. Take two positions of the top axis, a second of time in position apart. Lay off the (equal) angular momenta, $K\dot{\theta}$, along these



Φ, only.

axes. Then the arc b is the rate of change of angular momentum, and the angle, $-\dot{\psi}$, subtended, the speed in altitude. Hence

$$b = -K\dot{\theta} \cdot \dot{\psi}.$$

The arc, b, cannot be resolved with advantage, for there is no way of accounting for both components. Φ, however, may be resolved; for if one component is made parallel to b, this is the equivalent of b; whereas if the other component tends to twist across A (in a plane at right angles to 'around A'), *i. e.*, in the plane of this axis, it can produce stress only, but no motion. Hence, as seen in the figure, the effective *component* is $\Phi/\sin \psi$, a result a little subtle, I grant, but none the less logically straightforward. Therefore

$$\Phi/\sin \Phi = b,$$

whence

$$\Phi = -K\dot{\theta} \sin \psi \cdot \dot{\psi}.$$

Of course my explanation was intended for the man interested in *spinning* tops. The other man, who prefers the top toppling through all stages of inebriety, may take such solace as comes from products of parameter speeds and accelerations. But for him I have no message other than my blessing.

CARL BARUS.

BROWN UNIVERSITY, PROVIDENCE, R. I.

* Otherwise, if there is polar acceleration, $\Phi = -K(\dot{\theta}\dot{\psi} \sin \psi - \cos \psi \cdot \ddot{\theta})$ may be deduced without difficulty by the method of § II.

THE SOLAR ECLIPSE.

In view of the fact that some time must elapse before it is possible to publish a complete account of the results of observations on the solar eclipse of May 17th–18th, the following letter, written from Padang by a correspondent of the London *Times*, describing the preliminary arrangements, is of interest:

The last few days of our very prosperous voyage across the Indian Ocean in the Dutch mail boat *Koningin Regentes* have brought with them the sense that we are coming to a land where it is 'always afternoon.' But our days of eating lotus were nearly over just as we reached this beautiful land. The lighthouse close to Siberut, rising high above the palms, warned us that Padang was not more than ten hours away. The sight of this light produces the same thrill that seizes one when, after crossing the Atlantic, the Fastnet comes into view and tells that the voyage is safely accomplished. It is the first land that we sighted since we passed the splendid headland of Somaliland, Cape Guardafui, on March 27th; our course took us through the Maldives at night; and, though we passed through the '8° Canal,' Minicoy was left so far to the north that we got no glimpse of the light. All the members of the expedition who have traveled out by this direct route to make observations during the total eclipse of the sun visible in Sumatra disembarked at Padang.

Three parties of observers have traveled out on the *Koningin Regentes*—(1) the English expedition, consisting of Mr. H. F. Newall, of Cambridge, Mr. F. W. Dyson, of the Royal Observatory, Greenwich, accompanied by Mrs. Newall and by Mr. J. J. Atkinson, who has volunteered assistance to the party in this distant land, just as he did to the Astronomer Royal's party last year in Portugal; (2) the Dutch expedition, consisting of Dr. A. A. Nijland, of Utrecht, Dr. W. H. Julius, professor of experimental physics at Utrecht, and Mr. J. H. Wilterdinck, of the Leiden Observatory, accompanied by Mr. J. H. Hubrecht, a son of Professor Hubrecht, the eminent embryologist, who lately received the honorary degree of Sc.D. at Cambridge University; (3) a party from the Massachusetts Institute of Technology, consisting of Professor Burton, Mr. H. W. Smith, Mr. G. Hosmer, and Mr. G. H. Matthes. The instruments of all these parties were also carried by the same mail boat, which starts from Amsterdam and calls at Southampton and Genoa.

The eclipse of the sun which will occur on the 17th–18th of May is of special interest on account of the long duration of the total phase. The shadow of the moon will first touch the earth at sunrise near Madagascar, and in the course of the next five hours it will traverse a long path on the earth's surface. Passing at first in a northeasterly direction over Mauritius, it speeds across the Indian Ocean and traverses Sumatra and Borneo. It grazes the equator, but only a small part of the shadow touches the northern hemisphere. Then its course bends southeastwards and passes over the Malay Archipelago, Celebes, Seram, and thence over New Guinea. At sunset in the Coral Sea, between Melanesia and Australia, the shadow leaves the earth.

The partial phase of the eclipse will be visible over a vastly greater region of the earth's surface, as far north as Somaliland, India, Siam, and China, and also over the whole of Australia; but the real interest of the eclipse lies in the total phase, which can only be observed at stations lying on the line indicated. The shadow of the moon will be about 140 miles across as it passes over Sumatra, and it will travel with a speed of about 1,500 miles an hour. Hence any observer stationed near the path of the center of the circular shadow will be in the shadow for about a tenth of an

hour, or, if more exact calculations are used, for 6 min. 29 sec.

In recent eclipses the duration of totality has been much shorter; thus in America, Spain, and Algiers, in May, 1900, the total phase lasted not much more than one minute; whilst in India, in January, 1898, the duration was only a little more than two minutes in the most favorable stations.

Hence the coming eclipse is welcomed as an unusual opportunity for collecting observations by the photographic methods which play so important a part in modern investigations. Especially in spectroscopic researches is the photographic method serviceable; for by the nature of this kind of research the light gathered by the instruments is spread out over a much greater extent of the photographic plate. Accordingly to collect information about the spectrum of the faint light of the corona long exposures of the photographic plate are necessary.

The valuable information published by the *Koninklijke Natuurkundige Vereeniging* in Batavia over the signatures of Major Muller, the chief of the Trigonometrical Survey, and Dr. Figee, the director of the Meteorological Observatory, Batavia, showed that the weather conditions were probably most favorable, or, shall we say, least unfavorable, in Sumatra, especially near the west coast. It is therefore not surprising that most of the observing parties converge on Padang, the port that gives access to the province of the West Coast, and lies actually on the course of the moon's shadow.

The joint permanent eclipse committee of the Royal Society and the Royal Astronomical Society favored the sending of an expedition to Mauritius, and we understood on leaving England that Mr. E. W. Maunder, of the Royal Observatory, Greenwich, was to go thither to make observations in conjunction with Mr. Claxton, the director of the Royal Alfred Observatory, Mauritius. We also learn that Mr. D. P. Todd, of Amherst, U. S. A., is to be stationed at Singkep, an island noted for its tin mines, lying on the east coast of Sumatra, due south of Singapore. Otherwise all the observers have come to Padang and are receiving the most courteous and helpful reception by the Dutch authorities. Probably most of the parties have similar obligations to acknowledge. The English expedition received every assistance from Mr. Joekes, the Governor of Sumatra's west coast. Thus Mr. Dyson was at once made welcome to use the Government launch to make preliminary inspection of Trusan Bay and of the island Aoer Gedang, about six miles to the west of Painau and 30 miles to the south of Padang; whilst Mr. Newall received every assistance from Mr. Delpeat, the chief of the railways, to go inland and search for a suitable site on the east side of the Barisan Mountains. And so within four days of landing at Padang the sites for observing stations of the English expedition were chosen.

In order to increase the chances of securing observations of the eclipse, the parties distribute themselves as far apart as possible. The extreme stations in Sumatra are occupied by English parties. Mr. Dyson and Mr. Atkinson, assisted by his Majesty's ship *Pigmy*, a gunboat commanded by Lieutenant Oldham, R.N., and sent from the China Station to assist the observers, have established their camp on the island Aoer Gedang, and will be the first to catch the eclipse. Here the program of observations will be to secure (1) photographs of the corona on a large scale to show details of the structure; (2) photographs on a small scale to get the greatest possible extensions of the coronal streamers; (3) photographs of the ultra-violet spectrum of corona and chromosphere and also of the green and yellow spectrum, with slit spec-

troscopes in both cases. At the eastern extremity of the Sumatra stations Mr. Newall will be established at Doerian, above the Oembilien Coal Mines, near Sawah Loento, at the extreme end of the railway. The engineer of the mines, Mr. van Lessen, has put a house at the disposal of this party, and a very good site has been found close at hand for the setting up of the instruments, which consist of (1) a powerful flint spectroscope, to be used in an attempt to determine whether the corona rotates; (2) a quartz spectroscope, to be used for photographing the extreme ultra-violet spectrum and for a special search for Fraunhofer lines such as might be attributed to sunlight reflected by dust in the corona; (3) a cœlostat, to be used in connection (*a*) with polariscopic cameras in investigating the polarization of the light of the corona, (*b*) with a telephoto camera in photographing the corona, (*c*) with a powerful grating spectroscope in getting monochromatic images of the corona. This station is 1,200 ft. above sea level and it is at a considerable distance to the east of the main range of the Barisan Mountains. It is to be hoped that, with the considerable uncertainty that exists in the weather and wind conditions, one at least of these extreme stations may be favored with a good view of the eclipse. At various points between these extreme stations many other parties are established. The Dutch party have a large camp at Karang Sago, close to Painau, on the coast, and have an extensive programme, including (*a*) photographs of the corona with cameras of very varied dimensions ranging from a 40-ft. telescope with aperture f191 to a short camera with aperture f13.5; (*b*) spectroscopic observations of the corona and chromosphere; (*c*) polariscopic observations to be carried out visually; (*d*) measurements of the heat-radiation of the corona. (Professor Julius has constructed a specially delicate thermopile with a view of getting absolute measures of the total radiation of the whole corona and comparing it with that of the uneclipsed sun.) A party will probably also be sent with a prismatic camera to Fort de Kock, near the northern limit of the shadow.

The observers from the United States Naval Observatory, together with affiliated parties from the Yerkes Observatory and the Smithsonian Institution, are established in an excellent site, the old fort at Solok. Here Professor Barnard is setting up his cœlostat and 61-ft. telescope with which he is going to photograph the corona, exposing plates 40 in. square for 2½ minutes, being led to expect detail right up to the edge of these plates. For the shorter exposures he will be content to use smaller plates 30 in. square and 17 in. square. Professor Abbot and Mr. Draper, from the Smithsonian Institution, come with this party and find a room in the fort that will serve admirably for their bolometric apparatus. Dr. Humphrys will probably take spectrographic apparatus to Fort de Kock not far from the northern edge of the moon's shadow. Mr. Jewell brings out a battery of gratings of unusual size, both plane and concave, and will use films 36 in. long and 2½ in. wide in getting extended spectra of the chromosphere and corona, special attention being given to the ultra-violet region of the spectrum. Professor Skinner, who is in charge of the whole party, has also brought large cameras, which will be used in a search for an intra-mercurial planet.

Mr. Perrine, from the Lick Observatory, has established his camp on the race-course at Padang, and is setting up a 40-ft. telescope to point direct at the sun. He also has four 12-ft. cameras to be mounted on one axis and used in a search for Vulcan; in this research 12 plates, 17 in. by 14 in., will be exposed, covering a wide range on either

side of the sun, duplicate plates of each region being taken. He has also two spectroscopes, each with a single prism and with polarizing apparatus, for special study of the coronal light.

Members of the party from the Massachusetts Institute of Technology have found a good site near Sawah Loento, and are setting up in addition to their eclipse intruments, a number of geodetic instruments, among others a short-period pendulum. They also have a program of observations with magnetometers in continuation of their work in last year's eclipse, in which definite movements were detected in the magnets at the moment of totality.

The Japanese party, including Professors Shin Hiroyama and Seiji Hirayama, of Tokio, and five Japanese assistants, will probably find a station at Padang, as also will the parties from the Jesuit Colleges at Calcutta and Manila. We learn that a German expedition is to arrive on April 28th, and that Count de la Baume Pluvinel will arrive on the same date and proceed to Solok.

It is too early to speak of the chances of clear skies for the various parties, and at present it would seem that success is very precarious. It is fortunate that totality occurs at midday; the sky is frequently clear then, though many fleeting clouds pass over the sun. Meanwhile, the preparations are being pressed forward with a good will by observers and resident authorities alike.

SILAS W. HOLMAN.

SILAS WHITCOMB HOLMAN was born at Harvard, Massachusetts, Jan. 20, 1856, and graduated from the Massachusetts Institute of Technology in 1876, having made a specialty of the study of physics throughout his course. He was thereupon appointed to a position as assistant in the physical laboratory of that institution, but on account of illness did not enter upon his duties until a year later. Continuing in the service of the Institute, he was promoted to more advanced positions and was made professor of physics in 1893. Even at this date his health, never firm, had become much impaired, and a few years later it became necessary for him to relinquish active work. In 1897 he was made emeritus professor of physics. He died April 1, 1900.

Professor Holman's original contributions to science are of high merit and give evidence both of great skill in manipulation and of remarkably clear insight into the choice of methods for conducting a difficult investigation.

The most important of his researches are those upon the viscosity of air and carbonic acid as affected by temperature, which were published in the *Proceedings* of the American Academy of Arts and Sciences in 1876 and 1885, the first of which was based upon his graduating thesis at the Institute of Technology. These contain by far the most complete study of this difficult subject which had been made up to their date, and the results are still of standard value. Indeed, within the past few years, they have played an important part in the advancement of the kinetic theory of gases.

In the same *Proceedings* for 1886 is found a further noteworthy paper, written in conjunction with one of his pupils, upon the determination of fixed reference points for thermometric measurements at high temperatures in which several such points are established.

A number of years later, in 1895, appeared another group of papers, the last published by him, relating to the thermo-electric measurement of high temperatures, and a single paper upon calorimetry, which subjects had occupied much of his attention for some time previous. Of these, the one entitled

'Thermo-electric Interpolation Formulæ' is particularly valuable for its critique of the various methods of interpolation which have been employed in dealing with the results of high temperature observations, and that upon the 'Melting Points of Aluminium, Silver, Gold, Copper and Platinum,' published in collaboration with his pupils, Messrs. Lawrence and Barr, contains what are undoubtedly the best measurements of the points of fusion of these metals that had been obtained at the time of their publication. A third paper contains a description of a novel method of calibrating the LeChatelier thermo-electric pyrometer, and the fourth a new method of applying the cooling correction in measurements of the heat of combustion.

The papers of Professor Holman, thus far referred to, have all been published in the *Proceedings* of the American Academy. Several others of minor importance have appeared in different scientific journals. An extended critique upon thermometry of precision, presented at the Boston meeting of the American Association for the Advancement of Science in 1880 unfortunately was never printed.

Besides his published researches, Professor Holman was the author of several valuable scientific works. The two volumes of 'Physical Laboratory Notes,' prepared for the use of his pupils in the Massachusetts Institute of Technology, embody the results of many years of successful experience in teaching and form an important contribution to the literature of the subject. They contain much original matter and exhibit a rare discrimination in the selection and comparison of the methods of measurement which are discussed. This is particularly the case with the volume relating to electrical measurement and testing.

In 1892 he published a treatise upon 'The Discussion of the Precision of Measurements,' the basis of which consisted of the notes of lectures given to his classes. This volume, which is quite unique in its contents, contains in convenient form a very compendious and lucid consideration of the application of the principles of least squares to the theory of observations, the calculation of their precision and the choice of proportions in designing physical apparatus to be used for measurement. Its value as a text-book has been very great.

The collection of four- and five-place logarithmetic tables, prepared in 1896, embodies several features of marked originality, and is prefaced by a brief but exceedingly useful discussion of the fundamental principles of computation which contains many useful suggestions for the economizing of labor.

The last work written by Professor Holman, entitled, 'Matter, Energy, Force and Work,' appeared in 1898 and is of a character widely different from any of those which preceded it. It is a philosophical study of the fundamental concepts of modern physics, in which the subject is approached from the point of view that matter and energy, rather than matter and force, are the primary entities with which physics, has to deal, and that matter itself may be dependent upon energy for its own existence. While not technical in its character, and intended especially for the help of teachers not wholly familiar with modern views, it is distinguished throughout by great clearness and is a remarkable presentation of the newer modes of viewing the subjects which it considers.

Valuable as are his scientific publications, however, Professor Holman's great work was that of a teacher of young men in the laboratory. From the beginning of his service as an assistant in the Rogers Laboratory of Physics his influence was marked, and by his patient labors extending through many years, he brought the work which was under his charge to a high state of develop-

ment. He possessed great skill in the planning of apparatus and methods and remarkable judgment as to the processes best suited either for purposes of instruction or for the securing of accurate scientific results. To the development of the Laboratory of Electrical Measurements in the Massachusetts Institute of Technology he gave for years his best endeavors, and to him is due the success of its work. He was also placed in charge of the newly instituted Laboratory of Heat Measurements, and though prevented by failing health from developing this as he would have chosen, he laid a solid foundation for those coming after him.

Professor Holman was born a teacher, and never grew weary in his profession. His personal relations with his pupils were very intimate. By that example which is better than the wisest precept, he impressed upon them the preeminent necessity of thoroughness, accuracy and honesty in all the work which they might be called upon to perform, either as students or in professional life. He is remembered by them with the most affectionate regard.

Reference has already been made to the interference of ill-health with the prosecution of the labors of Professor Holman. In fact, after reaching manhood he was never in good health, and during almost the whole of his active life as a teacher he struggled with a painful chronic disease, which gradually, though with some intermissions, sapped his strength. His cheerful disposition and persistence in carrying on his work were such that none but those who knew him well were aware of the fact that it was only his indomitable courage which prevented him from yielding to his malady for some years before it finally overcame him. In the spring of 1890 he was obliged to discontinue work for a time. He spent the following year abroad and came home much improved in health; but the relief was only temporary. In 1895 he finally gave up his work of instruction. For some years after this, however, though confined to his chair and at last even deprived of his sight, he continued to labor diligently and published the tables of logarithms and the work on matter and energy mentioned above. His latest years were his best ones, and his whole life was a fine illustration of the manner in which a noble spirit may rise superior to circumstances and produce the best results under conditions to which an ordinary mind would utterly succumb.

CHAS. R. CROSS.

SCIENTIFIC BOOKS.

Botany—An Elementary Text for Schools. By L. H. BAILEY. New York, The Macmillan Company. 1901. 8vo. Pp. xvi + 356. Price, $1.10.

Foundations of Botany. By JOSEPH Y. BERGEN, A.M. Instructor in Biology, English High School, Boston. Boston, U. S. A., Ginn & Company. 1901. 8vo. Pp. xii + 412 + 258. Price, $1.50.

Within the past three or four months two notable text-books on high-school botany have appeared, the one from the ready pen of Professor Bailey, of Cornell University, to whom we are already indebted for so many helpful and suggestive books on various phases of plant life, the other from Instructor Bergen, of one of the Boston High Schools, who also has the distinction of having written acceptably in the preparation of an earlier, very useful, although much simpler, text-book for high-school students.

The two books are quite different in both content and mode of treatment. Professor Bailey takes the quite extreme position that 'the schools and teachers are not ready for the text-book which presents the subject from the viewpoint of botanical science,' and is particularly opposed to the use of the compound microscope in high schools, as when he says: "The pupil should come to the study of plants and animals with little more than his natural

and native powers. Study with the compound microscope is a specialization to be made when the pupil has had experience, and when his judgment and sense of relationship are trained." A little later he says: "It is often said that the high-school pupil should begin the study of botany with the lowest and simplest forms of life. This is wrong. The microscope is not an introduction to nature." We do not quite like the tone of non-approval in regard to science and specialists which is heard now and then in the author's preface, as in the first sentence quoted, where botanical science is referred to, and in this, "A book may be ideal from the specialist's point of view, and yet be of little use to the pupil and the school," and, "Every statement in an elementary text-book has two values—the teaching value and the scientific value," and, again, "Education should train persons to live, rather than to be scientists," and still, again, "Expert specialists are so likely to go into mere details and to pursue particular subjects so far, when teaching beginners, as to miss the leading and emphatic points." There is already too much of this feeling abroad in the land, as witness the recent discussions in Congress on matters of scientific importance, and there is no call for any one to increase it by discrediting any department of science or those who have devoted their lives to scientific work. Of course, we know that the author does not wish to be understood in this way, but his wording is unfortunate and will certainly be so understood by many people.

It would be unfair to quote the foregoing sentences, with the wording of which at least we most emphatically do not agree, and refrain from some quotation of those in regard to which there will be no question, as for example, "In the secondary schools botany should be taught for the purpose of bringing the pupil closer to the things with which he lives, of widening his horizon, of intensifying his hold on life," and, "Botany always should be taught by the 'laboratory method': that is, the pupil should work out the subjects directly from the specimens themselves."

The book is divided into four parts under the titles of 'The Plant Itself,' of 195 pages; 'The Plant in its Environment,' of 37 pages; 'Histology, or the Minute Structure of Plants,' of 42 pages, and 'The Kinds of Plants,' of 66 pages. The first is almost entirely devoted to the gross anatomy and elementary physiology of seed plants, but 24 pages being given to the structure of algæ, fungi, lichens, liverworts, mosses, ferns, horsetails and quillworts. The second part is ecological in a very elementary way, the treatment being well adapted to the needs of the pupils for which the book is designed. The third part, on the contrary, is quite severely technical, in spite of the author's prefatory remarks about the compound microscope, including such technical matters as fixing, imbedding, sectioning with the microtome, staining and mounting, and even not excluding karyokinesis! Part IV. consists of a handy little manual about 300 selected species of ferns and seed plants. Throughout the book the illustrations, of which there are 500, are very pretty, many of them being 'half-tone' reproductions of photographs.

We distinctly do not like the lists of questions at the close of the chapters, each question matching an italic or heavy-type sentence in the text. These will certainly lead to grave abuses. On the other hand, there is much to commend in the book. It is charmingly written by one who knows a great deal about plants, and who is desirous of having the young people know plants as he knows them. His enthusiasm will inspire many a pupil to take up the serious study of plants who otherwise might have passed them by had the subject been presented in a different way, especially where the teacher has little knowledge of botany.

In Instructor Bergen's book we have less divergence from the generally accepted principles in secondary botanical teaching. The author 'has attempted to steer a middle course between the advocates of the out-of-door school and of the histological school of botany-teaching.' That he is not afraid of the scientific or technical aspects of botany is shown by the following quotations:—"The latest authorities in the various departments of botany have been consulted on all doubtful points, and the attempt has been to make the book scientifically accurate throughout, yet not unduly difficult."

* * * "The author has no sympathy with those who decry the use of apparatus in botany teaching in secondary schools and who would confine the work of their pupils mainly within the limits of what can be seen with the unaided eye. If the compound microscope plainly reveals things shown only imperfectly by a magnifier and not at all with the naked eye, use the microscope. If iodine solution or other easily prepared reagents make evident the existence of structures or substances not to be detected without them, then use the reagents." * * * "When the university professor tells the teacher that he ought not to employ the ordinary appliances of elementary biological investigation in the school laboratory because the pupils cannot intelligently use them, the teacher is forced to reply that the professor himself cannot intelligently discuss a subject of which he has no personal knowledge." It is evident from the foregoing that the two authors approach the task of outlining the work for the pupil in the secondary schools with very different ideas as to what may be and should be done.

The book contains three parts, viz., 'Structure, Function and Classification of Plants,' 'Ecology, or Relations of Plants to the World about Them,' 'Key and Flora.' The first part begins with the seed and its germination, followed by chapters on the movements, development and morphology of the seedling, roots, stems, buds, leaves, flowers and fruits. In all this there are many physiological experiments, as well as much work with the compound microscope, one short chapter on protoplasm and its properties being interpolated. We have illustrated here, also, the usual exaggerated emphasis too commonly given to the flowering plants, which have 235 pages given to them as against but 63 pages for the slime moulds, bacteria, fresh-water and marine algæ, fungi, lichens, bryophytes, ferns and their allies. The second part is ecological, and follows the usual German treatment of this subject. It contains much interesting information, and pretty and suggestive pictures, but we do not look for much scientific training from the pupil's study of these chapters. At best the pupil will obtain but a very general and vague notion of the many things referred to here. Some serious errors mar this portion of the book, as in the treatment of 'plant formations' and 'prairies' on page 310.

The 'Flora' is much like most other manuals for beginners, which are made easy by the device of omitting certain families, which among teachers are reputed to be quite too difficult for the young student. It includes seed plants only.

CHARLES E. BESSEY.

THE UNIVERSITY OF NEBRASKA.

Text-Book of the Embryology of Invertebrates. By DR. E. KORSCHELT and DR. K. HEIDER. Translated from the German by MATILDA BERNARD. Revised and edited with additional notes by MARTIN F. WOODWARD. Vol. IV., Amphineura Lamellibranchia, Solenoconcha, Gastropoda Cephalopoda, Tunicata, Cephalochorda. London, Swan, Sonnenschein & Co., Ltd.; New York, The Macmillan Co. 1900. 18s.

This is the concluding volume of the somewhat tardy translation of Korschelt and Heider's standard 'Lehrbuch der vergleichenden Entwicklungsgeschichte der wirbellosen Thiere' 1893. As the editor notes in the preface, invertebrate embryology has made immense advances during the last eight years; thus a mere translation of the thorough and scholarly German work would fail to give an adequate account of the present state of knowledge. The translation itself by Matilda Bernard is a very faithful rendering into good English of the original. But the separation of the offices of translator and editor has necessarily limited the revision largely to numerous footnotes and some interpolations. This has the decided defect of preserving conspicuously all that later researches have shown to be errors in the original German edition, and of relegating the corrections to subordinate paragraphs or footnotes in small type easily overlooked by the average student. Thus, to take but a single example, the account of the cleavage of the lamellibranch ovum in the original has been shown to be incorrect, and it is illustrated by diagrams that faithfully and forcibly confirm the error. Yet both are given literally in the translation, and it would re-

quire one already versed in the literature to extract the truth from the footnote revision. Even, however, if the student succeeds in this, he will soon be confused by the plain unrevised statement on p. 106 that the course of cleavage is different in lamellibranchs and gastropods, whereas the recent work has demonstrated a fundamental similarity. It is also to be regretted that the editor should, apparently, have felt unable to replace some of the older figures with more accurate recent ones; not a single figure from the newer works is introduced.

A feature of the revision that will be heartily welcomed is the appendices to the lists of literature, in which the works published since 1893 are included. An important omission from the usually full and accurate lists is that of Heath's valuable paper on Ischnochiton, the more noticeable from the scantiness of the literature of the embryology of the Amphineura.

Misprints are not common, but it is rather a serious one that credits Hatschek's figures of the cleavage of *Amphioxus* given on p. 537, to Salensky. The present writer finds his initials once F. K. and again F. H., which arouses the suspicion that others also may have ground for complaint.

Take it all in all, the book is a good translation of the standard work on the subject, and the revision will at least suffice to guide the serious student to the more recent literature.

F. R. L.

The Play of Man. By KARL GROOS. Translated by ELIZABETH L. BALDWIN, with a preface by J. MARK BALDWIN. New York, Appleton & Co. 1901. Pp. 412. Price, $1.50.

This is not a drama, as the ambiguous title might signify, but a scientific treatise on sport and pastime, the performance of life's activities not for serious purposes, but for the solitary or cooperative pleasure in them. The author includes in his term the playful activity of the sensory apparatus in feeling, temperature, taste, smell, hearing and sight; the playful use of the motor apparatus, and the playful use of the higher mental powers. His second order of play is socionomic, that is, it takes two or more to fight, play chess, torment, haze, court, cooperate in diversion. The facts and results of over play and diseased play are not neglected.

Part III. is devoted to theoretical explanation of sport, the author finding its groundwork in the following:

1. The discharge of superabundant vigor—the physiological cause.

2. Activities of ancestors wrought in their children in the form of hereditary predispositions—the biological cause.

3. Pleasurableness and freedom from purpose—the psychological cause.

4. The enjoyment of imitating what produces agreeable or intense feelings—the esthetic cause.

5. The strengthening of the social tie—the sociological cause.

The closing pages are devoted to the relation of play to pedagogics. We have only space to quote one sentence, "At school one should learn to work, and he who does everything playfully will always remain a child." The reader will find throughout the work a becoming modesty in view of a new science, and a goodly portion of playfulness to relieve the monotony of dull classification.

O. T. M.

Text-book of Inorganic Chemistry. By VICTOR VON RICHTER. Edited by PROFESSOR H. KLINGER, University of Königsberg. Authorized translation by EDGAR F. SMITH, Professor of Chemistry in the University of Pennsylvania, assisted by WALTER T. TAGGART, Instructor in Chemistry. Fifth American from the tenth German edition. Carefully revised and corrected. With sixty-eight engravings on wood and colored lithographic plate of spectra. Philadelphia, P. Blakiston's Sons & Co. 1900. Pp. 430. $1.75.

The continued popularity of this book is shown by the frequent editions; in this edition, notices on liquid air, the new gases in the atmosphere, and ten pages of physical chemistry introduced into the chapter on metals, indicate careful revision, and a desire to bring the book up to date, without changing its general character. The characteristic of von Richter's book is the great amount of condensed

information which it contains compared with other books of its size; indeed, it might be criticized as giving too much for a text-book for beginners, too little for advanced students; yet as this has always been the characteristic of the book through the different editions, the popularity of the work may be held to answer such criticism.

E. RENOUF.

BOOKS RECEIVED.

Water Filtration Works. JAMES H. FUERTES. New York, John Wiley & Sons. 1901. Pp. xviii + 283.

Leçons sur les séries divergentes. ÉMILE BOREL. Paris, Gauthier-Villars. 1901. Pp. 183. 4 fr. 50 cts.

Essai sur les fondements de la geometrie. A. W. RUSSELL. Translated into French by ALBERT CADENAT. Paris, Gauthier-Villars. 1901. Pp. x + 274. 9 fr.

Moteurs synchrones à courants alternatifs. A. BLONDEL. Paris, Gauthier-Villars. 1901. Pp. 241. 3 fr.

The Sea-beach at Ebb-tide. A. F. ARNOLD. New York, The Century Co. 1901. Pp. x + 490. $2.40.

SCIENTIFIC JOURNALS AND ARTICLES.

The Journal of Comparative Neurology for April opens with two articles from the Neurological Laboratory of the University of Chicago, by Shinkishi Hatai. The first on 'The Finer Structure of the Spinal Ganglion Cells in the White Rat,' describes and figures two varieties of spinal ganglion cells and considers the smaller variety, the chromophilic cells of Nissl, to be an immature stage in the development of the larger variety. In the second paper, 'On the Presence of the Centrosome in Certain Nerve Cells of the White Rat,' the centrosome is described in nerve cells of new-born rats from the following localities: great pyramids of the cerebral cortex, Purkinje's cells, nucleus dentatus, ventral horn of spinal cord and spinal ganglion cells. The centrosomes were less easily demonstrated in the adult and were not found at all in some of these localities. Earl E. Ramsey, of Indiana University, describes 'The Optic Lobes and Optic Tracts of *Amblyopsis spelæus* DeKay,' a blind fish from the limestone caves of the Ohio Valley in which the eye and optic nerve are almost wholly degenerate. The optic lobes of the brain are greatly shrunken, the optic tracts and all parts of the optic tectum directly related to them are entirely wanting and the remaining layers are generally reduced in thickness. G. E. Coghill, of Brown University, discusses 'The Rami of the Fifth Nerve in Amphibia.' In the course of an examination of the nerve components of *Amblystoma*, he clears up the morphology and homologies of the maxillary and ophthalmic branches of this *Urodele* and of the frog. Dr. Strong (Columbia University) presents a 'Preliminary Report upon a Case of Unilateral Atrophy of the Cerebellum,' in which the left hemisphere of the cerebellum was almost completely wanting. Finally, 'A Bibliography of the Literature on the Organ and Sense of Smell' is given by Dr. H. Heath Bawden, of the University of Iowa. This list contains 885 titles, including anatomical, physiological and psychological subjects.

The Popular Science Monthly for May begins with an account of 'The Carnegie Museum,' by W. J. Holland. Frederick A. Cook describes 'The Aurora Australis,' as observed from the *Belgica*, with illustrations showing some of the many forms assumed by this interesting phenomenon, and we have the first instalment of a paper on the 'Progress and Tendency of Mechanical Engineering during the Nineteenth Century,' by Robert H. Thurston. An article on 'Primitive Color Vision,' by W. H. R. Rivers, gives a very good résumé of the evidence on which is based the deduction that color vision has been a comparatively recent acquirement of the human race, and the fifth portion of 'A Study of British Genius,' by Havelock Ellis, is devoted to childhood and youth. Under the title 'The Frog as Parent,' E. A. Andrews gives an interesting account of some of the curious breeding habits to be found among the frogs. In 'Recent Physiology,' G. N. Stewart tells of some of the lines of modern investigation and their results. The final paper, by David Starr Jordan, on 'The Blood of the Nation,' is a study of the decay of race through the survival of the unfit.

The Plant World for April contains the following articles: 'Hints on Herborizine,' by A. H. Curtise; 'Notes on the Flora about Nome City,' by J. B. Flett; 'The Native Oak Groves of Iowa,' by T. J. and M. F. L. Fitzpatrick, be-

sides brief articles, including a note on a fossil flower related to Hydrangea. The supplement, devoted to 'The Families of Flowering Plants,' by Charles Louis Pollard, treats of the Sarraceniales and Rosales.

AN editorial article in the *Observatory* accuses the *Astrophysical Journal* of reprinting without credit an article on the 'Siderostat' by M. Cornu. As the *Bulletin astronomique*, in which the French copy of the article appeared, was published in February, 1901, and the number of the *Astrophysical Journal* in March, 1901, the editor of the *Observatory* must appreciate the promptness of American methods. As a matter of fact important European articles on astrophysics are published by the authors simultaneously in the *Astrophysical Journal*. This makes the concluding sentence in the editorial in the *Observatory* interesting: "they print the same paper in several journals, so that it may be widely read, whereas in Europe we have made it a point *not* to reprint."

SOCIETIES AND ACADEMIES.

SECTION OF ANTHROPOLOGY AND PSYCHOLOGY OF THE NEW YORK ACADEMY OF SCIENCES.

A REGULAR meeting of the Section was held on April 22d, with Professor Farrand in the chair. Professor Eberhardt Fraas, of Stuttgart, a corresponding member of the Academy, was introduced by Professor Osborn, and briefly addressed the meeting.

Mr. A. L. Kroeber presented some 'Notes on the Arapahoe Indians.' In this paper the social and ceremonial organization of these Indians was compared with that of other Plains Indians. On superficial examination various tribes appear to be organized according to identical principles, but fuller knowledge generally reveals differences among the similarities. From this it was concluded that such terms as gens, band, age-fraternity and dance-society have no stable or exact meaning and hence little descriptive value, detailed information being the great desideratum.

Professor C. H. Judd reported an experimental study on 'Practice in Visual Perception.' It is a generally recognized fact that an illusion grows weaker as the observer becomes more familiar with it. A quantitative determination of the disappearance of the illusion seen in the Müller-Lyer figure was the subject of the paper. Two series of results were reported, one from an observer who looked forward to the disappearance of the illusion, the other from an observer who did not know that the illusion would disappear and did not discover that it was disappearing. In both cases the illusion disappeared in about 1,000 observations. The curves of practice differ in form and show many details of effects of pauses. In the case of the first observer the effects of the practice gained in the first series was easily marked in all the additional series which were performed with other figures and with other positions of the first figure. In the case of the second observer the effect of the practice was in some cases positive, but in one case it was so decidedly negative that it exaggerated the illusion and prevented any disappearance of it through a series of 1,500 observations.

Professor E. L. Thorndike, in a paper discussing the 'Origin of Human Intellect,' proposed as a working hypothesis that the development of ideation and rational thinking in the human species was but an extension of the typical animal form of intellect. He defended this hypothesis by showing that mere increase in the number, delicacy and complexity of associations between sense-impressions and impulses might give concepts, feelings of relationship and association by similarity as secondary results, that in the human infant this seemed to occur and that down through the vertebrate phylum a clear evolution of the associative processes along these lines could be traced.

The last report of the evening was by Dr. R. S. Woodworth, on the 'Voluntary Control of the Force of Movement.' By recording simultaneously the force of a blow struck by the hand and the extent of the movement preliminary to the blow, it is possible to see how far the force is dependent on the extent. The results showed a certain degree of correlation between the two, but comparatively a slight degree. The inference was that the force of the movement was only partially and loosely dependent on the extent, and that the control and perception of the force of a movement were in

some measure a direct and independent function.

R. S. WOODWORTH,
Secretary.

SECTION OF BIOLOGY OF THE NEW YORK ACADEMY OF SCIENCES.

A REGULAR meeting of the Section was held on April 8th, Mr. M. A. Bigelow presiding. The following program was offered:

E. B. Wilson: 'The History of the Centrosomes in Artificial Parthenogenesis, and its Relation to the Phenomena of Normal Fertilization.'

F. S. Lee: 'Some Observations on Rigor Mortis.'

In continuation of his communication given at the December meeting, Professor E. B. Wilson presented the results of further studies on the development of the unfertilized eggs of *Toxopneustes* when treated by Loeb's magnesium chloride method. The principal points considered were the origin and history of the centrosomes and the general relation of the phenomena to those occurring in normal fertilization. Evidence was brought forward that the cleavage centrosomes of the primary division figure arise by the division of a single primary centrosome that is formed outside, but immediately upon, the nuclear membrane. As regards the chromatic transformation of the nucleus, two types of chromosome formation were described. In both cases a large nucleolus is formed, which attains a much greater size than in the fertilized eggs. In one type this nucleolus remains a plasmosome, or true nucleolus, which fades away at the time of division, the chromosomes arising nearly in the usual manner from the chromatin network. In the second type, the entire chromatic content of the nucleus is gradually accumulated in the nucleolus, which thus forms a chromatin-nucleolus, from which the chromosomes are afterwards derived nearly in the same manner as in *Spirogyra*. In regard to the accessory asters, or cytasters, it was shown that they contain central bodies often indistinguishable in sections from the centrosome of the nuclear figure, though in many cases less well developed. Sections demonstrate that the division of the cytasters is preceded by division of the central body, which draws out to form a central spindle in a manner similar to that described by MacFarland in the eggs of gasteropods. This fact, taken in connection with the physiological activities of the cytasters, seems to remove every doubt regarding the identification of the central bodies as true centrosomes. In comparing the phenomena in the magnesium eggs with those of normal fertilization, it was pointed out that the formation of accessory asters at the time of fertilization or cell-division is a widespread phenomenon. In normal fertilization or division, the accessory asters are of very transient character. In the magnesium eggs they attain a much greater development both structurally and functionally, but they are probably to be regarded as differing only in degree from those which appear during the normal process. In all cases, their disappearance is probably due to a concentration of the protoplasmic activities about the more active centers, connected with the nucleus, which alone survive to perform the normal functions of division. Evidence was adduced that the nuclear transformation occurring in normal fertilization is not primarily due to the union of the sperm-nucleus, or sperm-centrosome with the egg-nucleus, but to a general stimulus of the ovum effected by the entrance of the spermatozoon. Apart from the different character of the stimulus, this transformation of the egg-nucleus does not differ essentially from that taking place in the magnesium eggs. This is proved by the fact that in etherized eggs the egg-nucleus may undergo the karyokinetic transformation *without union with the sperm-nucleus or centrosome* — an observation which agrees with the much earlier results of O. and R. Hertwig on eggs treated with chloral hydrate. In normal fertilization this activity of the egg-nucleus is modified through its union with an active individualized sperm-centrosome, the presence of which inhibits the formation of an egg-centrosome such as occurs in the magnesium eggs.

Professor F. S. Lee stated that rigor mortis is characterized by a shortening of the muscles of the body, accompanied by a coagulation of the contents of the muscle cells. The nature of the phenomenon is disputed. Hermann has long insisted that it is analogous to muscular

contraction and is the final vital act of the dying muscle cell. In connection with his studies of muscle fatigue, the author, with Mr. C. C. Harrold, has made some observations on cat's muscle, which seem to contradict Hermann's conclusion. Fasting, which is characterized especially by a diminution of the free carbohydrates in muscle, hastens the on-coming of rigor mortis. The administration of the peculiar drug, phlorhizin, which eliminates both the free and the combined carbohydrates, has a similar but much more pronounced effect. On the other hand, the ingestion of grape-sugar by a phlorhizinized animal delays rigor. Hence the conclusion seems justified that the absence of carbohydrates is favorable, and their presence unfavorable, to the development of rigor mortis. As regards the ability of the muscle to contract, carbohydrates have exactly the opposite effect, their absence being unfavorable and their presence favorable. Hence, in this respect, contraction and rigor mortis are not analogous processes.

HENRY E. CRAMPTON,
Secretary.

SECTION OF ASTRONOMY, PHYSICS AND CHEMISTRY OF THE NEW YORK ACADEMY OF SCIENCES.

THE section met on May 6th, at 8:15 P. M. The first paper of the evening was by Mr. C. B. Warring, entitled 'What Theology owes to Modern Science.' The paper was a very interesting interpretation of the Mosaic cosmogony in the light of modern scientific theories. The author defended the thesis that the order of events given in the cosmogony of Genesis did not necessarily contradict the order assumed by modern science. The paper was followed by a very interesting discussion.

The second paper of the evening, 'A Differential Astatic Magnetometer, suggested by Professor Rood,' was read by Mr. C. C. Trowbridge. The essential part of the instrument described is the suspension system, which consists of two groups of small magnets, set 23 cm. apart, rigidly connected by a fine glass fiber. The system is suspended by a single raw silk fibre 10 cm. long. By making the polarity of the two groups of magnets opposite, a system that is approximately astatic is obtained.

The object of the arrangement employed is partly to annul the effects of distant magnetic disturbing influences, such as those that arise from trolley car motors, etc., and partly to obtain a sensitive system that will act on the differential principle.

A magnet placed within a meter of the instrument and outside of the neutral plane between the two groups of magnets acts strongly on the nearest group, producing a deflection of the system.

The instrument was used in relative determinations of magnetic moments.

Mr. Trowbridge also gave a preliminary note on some experiments conducted by him on the influence of liquid air temperatures on the magnetization of steel and iron.

Magnets made from Crescent Co. and Sheffield magnet steels were chiefly tested.

The magnetic moment of bars magnetized at —186°C. and at 20°C. were found to be approximately the same, other conditions being equal. This was found to be true for both the steels mentioned.

Three Crescent steel bars magnetized at —186°C. were found to lose 38, 30.6, and 30.2, per cent. of magnetism when warmed to 20°C. A bar of this steel magnetized at 20°C. lost 9.5 per cent. of magnetism when cooled to —186°C.

These magnets after 9 days of approximately constant temperature at 20°C. were found to have further lost 6.1, 5.7, 8, and 12 per cent. of magnetism respectively.

Two bars made from Sheffield tungsten steel magnetized at —186°C. lost 12.2 and 15.7 per cent. magnetism when warmed to 20°C.

One bar of this steel magnetized at 20°C. lost 6.5 per cent. when cooled to —186°C.

A bar of Stubbs tool steel magnetized at 20°C. changed in magnetic moment, when cooled and heated between —186°C. and 20°C., as follows: at —186°m. —12.7; at 20° —30.5; at —185°, + 18 per cent.

Mr. Trowbridge stated that results similar to that found in the experiment with Stubbs steel have already been obtained by Professor Dewar.

F. L. TUFTS,
Secretary.

TORREY BOTANICAL CLUB.

AT the meeting of the Club on March 10th, Dr. Marshall A. Howe discussed 'The Algal Genera *Acetabularia* and *Acicularia*' in the light of specimens recently collected by him in the Bermudas. One of the specimens he had identified as *Acetabularia Schenckii* Möbius by comparison with type material from Brazil. Since its original collection in Brazil the species has been found, according to Count Solms-Laubach, on the island of Curaçoa, off the Venezuelan coast, and also in Guadaloupe, but its occurrence now in Bermuda, about a thousand miles further north, is a point of some interest. The aplanospores in this species surround themselves each with a thick calcareous shell and these shells adhere so that on the decay of the sporangium wall the spores are left in a single coherent mass. On this ground, Solms-Laubach refers *Acetabularia Schenckii* to the fossil genus *Acicularia*, hailing it as the only known living species. The generic separation from *Acetabularia* was thought by Dr. Howe to be defensible, but doubt was expressed as to the nature of *Acicularia pavantina*, the fragmentary fossil on which the genus *Acicularia* was established. Efforts are now being made to secure this *Acicularia* type for examination. With the aid of material preserved in formalin, stages in the development of the disk of both *Acicularia Schenckii* and *Acetabularia crenulata* were followed out which have been observed hitherto only in *Acetabularia mediterranea* and more completely in some respects than have been recorded for this species. This complete series of developmental stages of the disk seems to confirm, with much certainty, the morphological explanation of the disk put forward by Solms-Laubach in 1895. The disk as a whole is evidently not a complex aggregate of primary 'leaf-whorls' or primary whorls of sterile branches, as is taught by Wille in 'Die natürlichen Pflanzenfamilien' and by others, but is to be homologized with a single primary whorl of sterile branches, as has been suggested somewhat tentatively by Count Solms-Laubach. A point of some biological interest is found in connection with the aplanospores of *Acicularia Schenckii*, the walls of which are provided with a circular lid or operculum to permit the escape of the zoogametes. As the spores lie embedded in the calcareous massula the lid is always turned toward its surface and is but slightly, or not at all, incrusted with lime. It is expected that Dr. Howe's paper will be published in full in an early number of the *Bulletin*.

The second paper, by Mrs. E. G. Britton and Miss Alexandrina Taylor, was on the life-history of *Schizaea pusilla*, *Lygodium palmatum* and *Vittaria lineata*. Living and pressed specimens were shown of all three; also microscopic preparations and drawings illustrating the gametophyte from the spore to the sporophyte in the various stages of development. For *Schizaea pusilla* the exhibit of the life-history was very complete, and the descriptions and plates have already been published in the *Bulletin* of the Torrey Botanical Club for January, 1901. In *Lygodium palmatum* the development has been slow. During the winter, in the laboratory, the spores have germinated and formed an irregular protonemal growth, finally perfecting their normal prothallia, which are spatulate and bifurcated at apex. Thus far no antheridia or archegonia have been found. Of *Vittaria lineata*, fresh material was received from St. Augustine, Florida, early in February and a complete series of slides and drawings secured, showing a much branched thallus, bearing gemmæ at the extremities, as described by Goebel in certain East Indian species. The gemmæ were found bearing antheridia, radicles and young prothallia, evidently serving the double purpose of a sexual reproduction and cross-fertilization. The sporophyte in its young stages was also studied and the structure and venation worked out. Pressed specimens, named *Vittaria lineata*, were shown from the herbarium of Columbia University, which had been compared with Fee's monograph of the genus. Many of these were found to be incorrectly named as a comparison of the spores, sporangia and bracts at the base of the leaf proved.

Professor Underwood commented on the Linnean treatment of the *Vittarias*, and their subsequent mutations.

Professor Millspaugh, of the Field Columbian Museum, Chicago, spoke briefly on the results

of a recent trip to the West Indies for the purpose of studying the economic fruits of the tropics.

D. T. MACDOUGAL,
Secretary pro tem.

DISCUSSION AND CORRESPONDENCE.

BIBLIOGRAPHY OF GEODESY.

TO THE EDITOR OF SCIENCE: In the Report of the United States Coast and Geodetic Survey for 1887 there was published a Bibliography of Geodesy. Since the date named so many important contributions have been made to the literature of this subject that during the last meeting of the International Geodetic Association a resolution was passed requesting the undersigned to prepare a new edition of the Bibliography.

This work is now well under way, and every possible effort will be made towards making it complete. This desirable end can be attained only with the assistance of those authors who are good enough to send as soon as possible titles of their publications to the address given below.

As in the first edition, it is proposed to include all papers, books and reviews, pertaining to geodesy, least squares, figure of the earth, density of the earth and gravity determinations, including theoretical discussions of the pendulum.

In complying with this request, authors should give:

1. Full name.
2. Complete title.

a. If book, give size, number of pages in preface and in body of book, number of plates and illustrations, date and place of publication.

b. If in a serial publication, give name of publication, volume, and year and pages occupied by the contribution.

c. If a review, state the title of work reviewed.

In case the work has been reviewed, give name of reviewer and where the review may be found.

If preferred, in order to insure harmony in the form of making out the titles, publications may be sent to the undersigned. The International Exchange Service of the Smithsonian Institution has graciously consented to transmit such works as may be forwarded with the object named in view. They should be sent in my name to the Smithsonian Institution, Washington, D. C.

By giving this their early attention, author will confer a favor upon the compiler and upon those who may find it necessary to consult the work when published.

J. H. GORE.

COLUMBIAN UNIVERSITY,
WASHINGTON, D. C.

SHORTER ARTICLES.

NOTE ON THE WESTERN TERTIARY.

THE recently published discussion on 'The Freshwater Tertiary Formations of the Rocky Mountain Region,'* by Professor W. M. Davis, in which he indicates published evidence to prove those supposed lacustrine deposits not to have deposited in large lakes, but rather in regions of lakes and rivers, explains well the Eocene deposits which I have seen in northwestern Wyoming in the Bighorn basin. This region was visited by a party from the University of Minnesota in the summer of 1899.

The Eocene badlands there show an extent of horizontal strata which, when viewed as it is exposed for miles around one, does suggest at once a large filled lake basin. But there is a rapid alternation of clay and sand strata, and the several diverse kinds observed recur so unequally, and yet often so monotonously that the theory of a large permanent lake does not suffice to explain the phenomena. In fact while exploring for fossils I had the impression that we were not beyond the supposed lake's marginal zone, even when 40 miles or more from the formational boundary, and came finally to believe that this freshwater Tertiary might be different from others of the West. Professor Davis's argument now convinces me that it is not.

In order to find fossils rapidly one had to search out what we called rivers and bogs. The former are shallow trough-shaped beds of sand occurring either as intercalated masses or as thickened parts of a regular stratum. The bogs occurred here and there, more or less

* *Proceedings Am. Acad. Arts and Sci.*, Vol. XXXV., p. 345.

clearly indicated by color and by small rough clay-iron residuum when weathered. Fossils occurred most frequently in those deposits and one became aware of their discontinuity when trying to follow them in search of their contents. The sand troughs or rivers yielded the whole bones, *i. e.*, vertebræ with processes and even rarely whole skeletons. The bogs yielded fragmentary bones. These were found to have been gnawed, as a rule, and the gnawing had been done also where they now lie in the strata. Legs were found bitten off at the knees, as if the animal had mired and its buried parts thus escaped being devoured. Also numerous fragments of, evidently, a single animal would occur scattered about, the ends and thin parts of bones being gnawed off. For example, more than once a Coryphodon's large tooth was found with the surface, including the enamel, chiseled off by some corrugated tooth, probably that of some Tillodont mammal. Plates of turtles' plastron had likewise been nibbled all around their margins. In fact, worthless fragments composed the greater part of the fossils.

When one had become skilled in detecting the differences between those pieces fractured before, and those after, fossilization, many strange things began to be evident, such as fragments taken from the same stratum at some distance apart, proving to be those of one bone; and again fragments representing the same parts of several animals occurring in one spot, the other parts of all being absent. A lot of molar teeth and an odontoid process seem often to represent a head and neck. This all appeared to be incidental to the feasting that had preceded fossilization.

That crocodiles and turtles may have done the gnawing in part was suggested by their fossil remains, but that the chiseling process was theirs could not be maintained. In some cases, maceration had left the bones shapeless or thickly encrusted with iron. And this maceration as well as the chiseling might well argue the subaerial deposition of the bones.

I may mention also two geologically significant phenomena which require close observation to distinguish them. Original stratigraphic inequalities, amounting sometimes to local unconformability, might be passed unnoticed among the numerous similar looking inequalities due to unequal induration of the rock, the latter being intimately associated as to its cause with the physiographic changes now developing. And the color banding may be both original stratigraphic and secondarily modified. I remember one fine example of a large trough filled with a series of clay and sand strata, seen at a distance on the left of the trail ascending Tatman's butte to the Buffalo basin. But not having had time to examine it minutely, I scarcely dare assert that it might not be secondary cross-coloring. Close at hand one would not have noticed it, because the whole could not have been seen, and the slow thinning out of individual strata would be nothing unusual. Expeditions into badlands for the purpose of collecting fossils can not well take time in one season to gather and verify occurrences sufficient to prove the exact geologic nature of the deposit of part, much less the whole, of a basin, which, however, expeditions for that express purpose might do.

FREDERICK W. SARDESON.
UNIVERSITY OF MINNESOTA,
April 6, 1901.

AN UNUSUAL TYPE OF AURIFEROUS DEPOSIT.

ONE of the most unique deposits of gold-bearing material which the writer has ever seen has been worked during the past three or four years at the King Solomon mine. It is situated near the summit of Cañon mountain, in the basin of the South Fork of Salmon river, in the southwestern part of Siskiyou county, California.

The ore consisted of a body of semi-decomposed country-rock, including micaceous schist, slate and greenstone, heavily stained with the oxides of iron and manganese and containing fine particles of free gold disseminated through it. The deposit had a length of about 500 feet, an average width of 60 feet and mainly a workable depth of 50 feet, although a much narrower body of ore continues to greater depth. Mining operations have been conducted in several large open pits, beneath the floors of which have been excavated tunnels. The ore is shoveled from the loose crumbling slopes of the pits into

barrows, then wheeled and dumped through chutes in the floor, and hauled out of the tunnels in cars.

Along certain narrow streaks the ore was of good grade, carrying values as high as several hundred dollars to the ton; but it has been the policy of the company to work the deposit on a large scale and in a cheap manner; hence, everything has been removed which contained sufficient gold to pay a small profit. In this way the average yield per ton of the ore was, during the first few years, brought down to $7 and even $5 in gold and later this was further decreased to $3.50. From month to month the ore showed a remarkable uniformity in tenor, although but 40 to 70 tons were handled per day, and this was taken haphazard within the limits of what was determined to be the ore-body.

Running through the center of the deposit, and parallel with its major axis, there was a narrow dike of white acid porphyry, such as is commonly associated with gold-bearing veins of this region, and the entire ore-body has frequently been reported as a mineralized dike. However, the acid dike is not ore, but is thrown away as waste. On both sides the ore-body extended away from it to a distance of 20 to 50 feet and terminated irregularly in the mass of the decomposed rock, there being no well-marked walls or other evidences of common vein action. The grade of the ore was closely connected with the intensity of the iron stain and particularly with the quantity of brown manganese oxide present.

At first thought, this large deposit of red, soft, decomposed rock carrying free gold was considered the upper or oxidized portion of a zone of impregnation of auriferous sulphides such as are rather common in this northwestern California region; but a consultation with the superintendent of the mine, Mr. F. N. Fletcher, brought to light some facts which demonstrate that it is certainly of an entirely different character. It is unique among deposits of this country in the following two points:

1. It is absolutely free from any traces of pyrites changed to limonite such as are always found in panning the surface portion of other veins.

2. It does not present any evidence of passing in depth into a shear zone modified by solfataric action and impregnated with auriferous sulphides.

Upon first arrival at the mine, the writer was impressed by the marked resemblance in the tint and character of the deep red staining to those of certain accumulations of residual red clay found frequently in hollows in the surface of limestone formations, as, for instance, over the Galena limestone in the Mississippi basin. This suggested an explanation for the origin of the deposit which was subsequently worked out as follows:

The site of the King Solomon mine, which is at present the top of a mountain ridge, was once the bottom of a rather deep, broad basin eroded by subaerial agencies from a series of quartzites, black slates and limestone. This series was intersected by numerous narrow branching dikes of greenstone. Evidence that a small amount (say a trace) of gold was a primary constituent of this system of eruptives has been found in different parts of this country.

The carbonated meteoric waters circulating laterally and downward beneath the slopes of the basin, dissolved gold out of these greenstone dikes and carried it, along with iron and manganese salts (derived from pyrites in the quartzites and slates), to the center of the basin, where, just beneath the surface, these minerals were precipitated as free gold, ferrous carbonate or hydrous ferric oxide and some salt of manganese, perhaps the last in its present form of oxide. Precipitation was probably due, as in the case of limonite and wad in bogs, to the decreased circulation of the water at the center of the basin, and in part also to the water rising close to the surface and becoming subjected to the oxidizing influence of the atmosphere.

Subsequently, through great erosion of the region, the water level was depressed in the strata, the basin no longer existed, and the limonitic deposit worked downward, penetrating to unequal depths in different places. The porous schists and slaty rocks were deeply stained with the oxide and impregnated with gold, but the acid dike in the center of the deposit was largely impervious to the solution and escaped heavy mineralization.

In short, the King Solomon ore-body has had a mode of formation roughly analogous with that of the limonite ore deposits of the Great Valley of the Appalachian region, and of the limestone regions of southern Missouri. Such accumulations of ferruginous matter as the result of deposition from waters of ordinary surface temperature, and circulating within several hundred feet of the surface of the earth, are of common occurrence in many parts of the world, and may be found in other sections of northwestern California, but they are not often auriferous to an appreciable extent. It is its gold contents which make this King Solomon deposit so remarkable.

To the writer, the scientific interest of the preceding facts appears to be in their bearing on the question of the power of ordinary subsurface waters to dissolve and redeposit gold under conditions not favorable to the production of iron pyrites. We seem to have here a clear case where metallic gold has been put through the same process of solution, concentration and precipitation as has the staining material, the oxides of iron and manganese.

OSCAR H. HERSHEY.

BERKELEY, CALIF., Jan. 20, 1901.

CURRENT NOTES ON PHYSIOGRAPHY.

TALLULAH GORGE, GEORGIA.

THE studies of Hayes and Campbell on the southern Appalachians have made us familiar with the general features of a contested drainage area in northeastern Georgia, where the headwaters of the Savannah (Tugaloo) river are capturing those of the Chattahoochee. Some further details of the changes thus effected are described in a brief essay on 'the Geology of the Tallulah Gorge,' by S. P. Jones (Amer. Geol., XXVII., 1901, 67–75). The gorge is narrow, steep-sided, and over 500 feet deep; the river flows through it in a succession of cascades and rapids; it is evidently a young river course. The precise order of events in the development of the gorge does not appear to have been made out; indeed the author here cited does not seem entirely convinced of the process of capture as an efficient cause for the new order of things. Yet it is certainly significant that the gorge, unusual if not unique in sharpness of form among the southern Appalachians, should occur in immediate association

with a group of features whose systematic relations would seem to point unequivocally to the invasion of one river basin by the head branches of another.

In view of the open form and gradual descent of the Chattooga valley in contrast to the narrowness of the Tallulah gorge and the rapid descent of the river through it, one may reasonably conclude that the first was captured much earlier than the second. This makes it seem probable that the Tallulah formerly followed a course near the railroad line, and that its entrance into the Chattooga is the result of diversion by the headward growth of a creek on the line of the gorge; although a somewhat different opinion is expressed in the article here abstracted.

PREHISTORIC LANDSLIDES IN THE ALPS.

CERTAIN Alpine valleys contain huge accumulations of mountain waste, described as moraines by earlier observers, but now interpreted as landslides (see SCIENCE, II., 1895, 618). The latest special study on this subject is by J. Oberholzer ('Monographie einiger prähistorischer Bergstürze in den Glarner Alpen,' Beitr. Geol. Karte der Schweiz, n. f., IX. Lief., Bern, 1900). It discusses a number of large prehistoric slides in the neighborhood of Glarus, giving abundant details as to structure, source, path, volume, etc. A colored map, 1 : 20,000, shows the geological formations of the district in the slides as well as in the mountains. Some of the slides still bar their valleys and hold back lakes;

others have been trenched by streams. All show more or less distinct changes of form by weathering and washing (especially where torrent fans are built upon them), although generally retaining something of the tumult of surface that characterizes recent slides. One of the slides (that by Schwanden in the Linththal) has a small amount of morainic material strewn over its surface, as well as more abundant moraine beneath it; and from this Oberholzer concludes that it occurred during the last interglacial epoch. But inasmuch as its surface is still very uneven, it can hardly be believed that it has been overridden by more than a small and short-lived glacier.

No reference is made to the suggestion, which is certainly gaining ground among Swiss observers, that the landslides of the class here described result from the oversteepening of the basal slopes of valleys that have been overdeepened by glacial erosion.

THE GREAT AFRICAN LAKES.

THE peculiar likeness of the fauna of Lake Tanganyika to marine forms has prompted a special study of the Great African Lakes by an expedition under the direction of J. E. S. Moore, whose report contains matter of much value (Tanganyika and the countries north of it. Geogr. Journ., XVII., 1901, 1–35).

North of Tanganyika, the floor of the great rift valley or *graben* in which the lakes lie rises to form a strong barrier which once constituted part of the divide between the Congo and the Nile drainage systems. But now a group of large and active volcanoes some 50 miles further north, one of which is 13,000 feet high, have built a second barrier on the valley floor, thus cutting off the basin of Lake Kivu from that of Albert Edward Nyanza, and raising the former nearly 2,000 feet. That Kivu was once tributary to the Nile is clearly shown by its fauna, which is in nearly all respects identical with the normal fresh-water lake fauna of the Nyanzas to the north; but its outlet, Rusisi river, now flows south with many cataracts over the rocky swell in the valley floor, thus connecting Kivu with Tanganyika; and it is evidently since this connection was made that a fish characteristic of the Congo basin has reached Kivu. The rift valley, the active volcanoes far inland, the great lakes and their peculiar fauna combine to make this a region of remarkable interest.

W. M. DAVIS.

RECENT PROGRESS IN PALEONTOLOGY.

CONGESTION OF MUSEUMS.

IT is very important that the various museums of the country should receive special funds with which to work up the collections of vertebrate fossils that are rapidly accumulating. Much more time is required in preparing a fossil than is spent in collecting and shipping it from the field. The result is that all the museums of the country which have been collecting during the past few years are greatly congested with material. According to a moderate estimate, from five to fifteen years of constant work must be spent upon the collections now in each of our museums. The delay in working up fossils of various types threatens to cause serious inconvenience and delay in the matter of publication. Even highly trained preparators are unable to prepare a fragile fossil rapidly. Some single dinosaur vertebræ, for example, are so broken that from a month to six weeks must be spent upon them. The collections which have already been made in the West fill thousands of boxes, and the most welcome gift which could be made to any of our museums would be a gift especially for the purposes of preparation.

SPECIAL INVESTIGATIONS.

A GRATIFYING division of labor is in progress among the vertebrate paleontologists of the country. In Kansas University, Professor Williston is beginning a very careful study of the Plesiosaurs, which will form a sequel to his admirable memoir upon the Mosasaurs. In the University of California, Dr. Merriam is making a special examination of the John Day fauna. In Yale University, Dr. Wortman is thoroughly revising the rich collections made in the Eocene or Bridger beds, and will publish a series of papers illustrating Professor Marsh's principal types. In the American Musuem, Dr. Hay is especially studying the fossil Chelonia of the American Museum and Cope collections; Dr. Matthew is making a study of the Creodonts of

the Miocene fauna of Kansas and eastern Colorado, of which much remains to be done; Mr. Gidley is working upon the Pleistocene horses, and has just completed a very careful revision of the species; Dr. McGregor is working upon Belodon and the Phytosauria, comparing the American and German types; Professor Osborn is especially studying the Titanotheres. At Princeton, Professor Scott is working up the Patagonian mammals. In the Carnegie Museum, Mr. Hatcher has just completed a memoir upon Diplodocus.

EVOLUTION OF THE HORSE.

A FRIEND of the American Museum of Natural History has recently presented a fund, which is to be used exclusively for the collection, exhibition and study of the fossil horses of America. Professor Osborn has planned two expeditions for the coming season, with the especial object of filling gaps in the already rich series. It is proposed also to mount as complete a series of fossil skeletons as possible, showing all the chief stages in the evolution of the horse from *Hyracotherium* to *Equus*. Four complete skeletons have already been procured, two of which have been mounted. It is also proposed to exhibit recent types of skeletons, showing the effects of artificial selection. H. F. O.

AN ARCHEOLOGICAL MAP.

BENEDICT'S map of Chain-O'-Lakes, near Waupaca, Wis., copyrighted by F. M. Benedict in 1896, although not well known, is yet of considerable value and interest to archeologists. It locates the Wisconsin and Wolf River Indian trail, and by numbers indicates village sites, a bake hole, kitchen middens, graves, and conical, ovals and effigy mounds.

The location and description of such remains, however brief, are always valuable. The great number of archeological sites, and the comparative ease with which they could now be located and described, seem to cause local students to ignore the great need of present work in this line. They do not realize that the facilities for the work at the present time are far better than they will be a few years hence, when but a fragment of the same results could be accomplished. Mounds plowed over are harder to find, and crops ruined by the excavations of the explorer are more expensive than anything injured on wild land. Permission of owners is also harder to secure in more thickly settled regions. In this connection Mr. Benedict's efforts certainly are commendable.

It is very desirable that such a map be constructed by every local student or lover of archeology, until every county in the country is covered. It might be saved for future use either by being published or by filing duplicate copies of it in several libraries or museums. Certainly specimens found by such students deserve a careful record and preservation in the nearest substantial public museum or college.

HARLAN I. SMITH.

THE BIOLOGICAL STATION OF THE UNIVERSITY OF MONTANA.

THE Biological Station of the University of Montana will be open for its third season beginning July 22d, for four weeks. The laboratory is near the P. O. of Holt, Montana, at the northern end of Flathead Lake, and from it a great variety of collecting grounds is easily accessible: Flathead Lake is 32 miles long and 16 wide, with an elevation of 4,000 feet; Swan River debouches into the Lake near the station, and numerous other large and small streams, swamps, smaller lakes, forests and mountains with an altitude of ten thousand feet offer a variety of conditions not within reach of many similar institutions.

Courses in zoology, botany, ornithology and nature study will be offered. A small party will leave Missoula early in June and will make explorations in the Cabinet or Mission mountains, reaching the Laboratory at the beginning of the sessions.

The facilities of the station which are placed at the service of students and investigators embrace a gasoline launch, row-boats, botanical apparatus, insect nets, pumping apparatus, etc., and a team and wagon equipped with camping outfit.

The New York Botanical Garden will coöperate in the botanical work of the Station. Dr. D. T. MacDougal, director of the laboratories in that institution will join the party in

the field for the purpose of making collections, and pursuing some investigations upon the relations of climate and vegetation, and will continue both lines of work at the Station; the botanical work during the season will be under his guidance. Attention will be given to general botany, and to the special features of the flora of Montana. Mr. R. S. Williams, of the same institution, will spend the month of June in making collections in the northwestern part of the State, and will be present during a part of the session, giving especial attention to mosses and ferns.

No tuition fees are charged either to students or investigators; microscopes and glassware are supplied free, but the worker is expected to meet the cost of material actually consumed.

Applications and correspondence should be addressed to the Director, Professor Morton J. Elrod, Missouli, Mont., until July 10th; after this date to the Biological Station, Holt, Flathead Co., Mont.

SYNTONIC WIRELESS TELEGRAPHY.

At a meeting of the Society of Arts, on May 15th, Mr. Marconi read a paper on 'Syntonic Wireless Telegraphy.' In the course of his paper, according to the report in the London *Times*, he gave an account of two methods by which he has been able to arrange a selective action in his instruments, so that, for example, two stations can converse with each other without being overheard by an intermediate one. In the first he employed an ordinary vertical radiator placed near an earthed conductor, the effect of the latter being to increase the capacity of the radiating vertical wire without increasing its radiative power; in this way syntonic results were obtained without difficulty. In one form of this arrangement the radiating and resonating conductors consisted of a cylinder, the earthed conductor being placed inside. Using cylinders of zinc only seven meters high and 1½ meters in diameter, good signals were obtained between St. Catherine's Point and Poole (50 kilometres distance), which were not interfered with or read by other wireless-telegraph installations at work in the immediate vicinity. The closely adjacent plates and large capacity of the receiver caused it to be a resonator with a very decided period of its own, and, therefore, it was not apt to respond to frequencies differing from its own period, or to be interfered with by stray ether waves, such as were sometimes caused by atmospheric disturbances, and occasionally proved troublesome in the summer. His second syntonized system was the outcome of experiments with the discharge of Leyden jar circuits. Taking for granted that the chief difficulty with the old system lay in the fact that the oscillations were very dead-beat, he tried, by associating with the radiator wire a condenser circuit known to be a persistent oscillator, to set up a series of persistent oscillations in the transmitting vertical wire. In one application of this principle the vertical conductor was connected to earth through the primary of a transformer, the secondary of which was in circuit with the coherer, and, in order to make the tuning between these two circuits more marked, an adjustable condenser was placed across the coherer. To obtain the best results, it was necessary that the free period of electrical oscillations of the vertical wire primary of the transformer should be in electrical resonance with the secondary of the transformer which included the condenser. It was easy to understand that, if there were several receiving stations, each tuned to a different period of electrical vibration, of which the corresponding inductance and capacity at the transmitting station were known, it would not be difficult to transmit to any one of them without danger of the message being picked up by the others for which it was not intended. But, further, it was possible to connect to the same vertical sending wire, through connections of different inductance, several differently tuned transmitters, and to the receiving vertical wire a number of corresponding receivers; then different messages could be sent by each transmitter to the radiating wire simultaneously, and received simultaneously by the vertical wire connected to differently tuned receivers. A further improvement had been obtained by the combination of the two systems described in the paper, the cylinders being connected to the secondary of the transmitting transformer and the receiver to a properly tuned induction coil, with

all the circuits tuned to the same period. The fact that signalling had been successfully carried out over a distance of 50 kilometers with a cylinder only 1.25 meters high and one meter in diameter led to the possibility of constructing portable apparatus for use in the field. He had designed a complete installation on a steam motor-car, on the roof of which was placed a cylinder, only six or seven meters high, that could be lowered while traveling. By means of this, communication had easily been carried on with a syntonized station 50 kilometers distant, a 25-cm. spark induction coil, taking about 100 watts, being used for transmitting. A strip of wire netting dragged behind the car was sufficient for earth connection, or in lieu of any earth connection the electrical capacity of the boiler might be utilized. As to the distance over which signalling had been effected, last spring he established a station at the Lizard and opened communications with St. Catherine's—a distance of over 300 kilometers. The amount of energy used in this case was not more than 150 watts, and the aerial conductor consisted of four parallel vertical wires 1½ meters apart and 48 meters long, or of a strip of wire netting of the same length. In conclusion, Mr. Marconi gave some examples of the progress made in the practical utilization of his system, and also briefly examined a method proposed by Professor Slaby.

WIRELESS TELEGRAPHY IN THE NAVY.

ADMIRAL BRADFORD, chief of the naval bureau of equipment, has given out the following extract from the report of the board which has investigated the question of transmitting messages by wireless telegraphy:

"From the examination of the subject, as outlined in the orders of the department, the board makes the following recommendations:

"1. That the use of homing pigeons be discontinued as soon as wireless telegraphy is introduced into the navy.

"2. That, pending such action, no new pigeon codes be established.

"3. That wireless telegraphy be adopted by the navy for transmission of messages between distant points.

"Referring to the last recommendation, the board is of the opinion that a high degree of special electrical training is demanded for the successful operation of any system of wireless telegraphy, and it therefore suggests as necessary the establishment of two stations sufficiently far removed from each other for the training of officers and men.

"In its opinion this requirement would be best met by the establishment of such stations at the Navy Yard, Washington, and the Naval Academy, Annapolis. If wireless telegraphy fulfills what now seem to be its possibilities, the cadets should be thoroughly trained in it.

"As the investigation made by this board is not technical, there being no apparatus of any kind ready for test, but general in its character, such partial examinations as outlined above would not change the recommendations already made.

"The selection of any special system of wireless telegraphy is, in the opinion of the board, very largely a matter of business detail.

"If for any reason any competitive test of different systems is thoroughly desirable the board recommends, in view of the fact that the improved Marconi apparatus will not be available for several months, and that improvement in other systems may occur in that interval, that it be made only after due notice and preparation therefor, and by a special board of experts appointed for the purpose."

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

ARRANGEMENTS for the Denver meeting of the American Association for the Advancement of Science are locally assuming very definite shape. A meeting of the Colorado Science Teachers Association was held in Denver on May 11th and all the members of the American Association residing in Colorado were invited to attend, a special point being made in the call that the meeting would consider the August meeting of the American Association. The cooperation of the Society was pledged to the Local Executive Committee, and the committee itself was organized by the election of Mr. George Lyman Cannon as chairman and Mr. Arthur Williams, secretary of the Chamber of Commerce and Board of Trade, as secretary.

Mr. Jas. F. Callbreath, Jr., editor of the *Mining Reporter*, was appointed chairman of the committee on printing and will at once proceed to publish the Preliminary Announcement, which will be distributed to all members of the Association.

The permanent secretary has as yet been unable to secure definite information regarding the railroad rates. This is the first time the Association has met in the far West and all the passenger associations are holding their decisions contingent upon that of the Western Passenger Association, in whose territory the meeting is to be held. This association is not in the habit of taking definite action on meetings of this character until within 60 days of the meeting, and this has complicated the railroad question. The peculiar character of the Association, in that it is composed so largely of men connected with college faculties, who have a long summer vacation and desire to make their plans well in advance, and, in fact, the majority of whom leave home after commencement and are difficult to reach by mail, has been shown to the railroad people and a speedy decision is hoped for. The permanent secretary thinks it most probable that a rate of not to exceed one fare plus $2 will be secured for the territory west of Chicago, and surely the passenger associations east of Chicago will make a rate at least as low as one fare and one-third. An effort is still being made to secure a one fare rate for the entire trip.

SCIENTIFIC NOTES AND NEWS.

PROFESSOR WILLIAM JAMES, of Harvard University, began his course of Gifford Lectures at Edinburgh on May 16th.

THE Paris Academy of Sciences has elected Dr. Zeuner, of Dresden, a correspondent in the section of mechanics. The other nominations were: Professor Henry T. Eddy, University of Minnesota and Professor Zabonsdsky, of St. Petersburg. In the section of geography and navigation, Dr. Oudemans, of Utrecht, was elected correspondent. The other nominations were: Mr. Wharton, of London, Professor Albrecht, of Potsdam, and Professor Neumayer of Hamburg.

THE following have been elected honorary members of the American Chemical Society: Professor William Ramsay, University College, London, Sir Henry E. Roscoe, University of London, Professor Emil Fischer, University of Berlin, Professor Adolph Baeyer, University of Munich, and Professor George Lunge, University of Zurich.

SIR WILLIAM MACCORMAC, president of the Royal College of Surgeons, London, has been elected a foreign associate fellow of the College of Physicians of Philadelphia.

MR. WILLIAM WHITWELL has been elected president of the British Iron and Steel Institute in succession to Sir William Roberts-Austen.

MR. W. LANGDON has been nominated for the presidency of the Institution of Electrical Engineers, London.

THE Linnean Society, London, has awarded its gold medal to Lieutenant Colonel Sir George King, the botanist, lately superintendent of the Royal Botanic Garden at Calcutta. He has published important monographs on the flora of India, China and the Malay Peninsula.

THE Bessemer Gold Medal of the British Iron and Steel Institute has been conferred upon Mr. John Edward Stead, F.I.C., in recognition of the value of his investigations of the physical and chemical properties of iron and steel.

DR. G. T. MOORE, of the department of biology at Dartmouth College, has been appointed algologist in the Department of Agriculture.

Nature states that news has been received of the safety of Professor W. Baldwin Spencer and Mr. Gillen. They report themselves in good health and already busy taking phono- and kinematographic records. The Postmaster-General of South Australia has provided them with pocket apparatus for tapping the overland telegraph line when in the vicinity of their route.

THE president of the University of Tokyo, Deiroku Kikuchi, will represent Japan at the bi-centennial celebration of Yale University next October.

KING EDWARD VII. has consented to be patron of the British Medical Association.

A DEPARTMENT of experimental psychology has been established in connection with the Pathological Laboratory of the London County Council Asylums at Claybury. Dr. W. G. Smith, recently of Smith College, Northampton, has been placed in charge.

DR. OTTO LUGGER, State entomologist of Minnesota, died of pneumonia on May 21st. Dr. Lugger was an entomologist of wide reputation. He was assistant to the late Professor C. V. Riley at the time when the latter was publishing his well-known 'Reports on the Insects of Missouri.' Subsequently he became curator of the Maryland Academy of Sciences and, still later, an assistant in the Division of Entomology, U. S. Department of Agriculture, from which place he went to Minnesota as State entomologist in 1887. The latter office he has held for nearly 14 years with great success. His reports have been models of their kind and his investigations along certain lines have been of great value to agriculture.

DR. WILLIAM D. THOMAS, professor of psychology in Richmond College, Va., died on May 22d.

THE death is announced of Dr. E. Bretenschneider at St. Petersburg. He was for many years physician to the Russian Legation at Pekin, and made important researches on Chinese archeology, geology, etc. His books include two on Chinese botanical work.

THE death is also announced of Dr. Peter Helmling, formerly professor of mathematics at the University of Dorpat, at the age of eighty-four years, and of Dr. George Asp, professor of anatomy at Helsingfors.

The officers of Section C, Chemistry, of the American Association have issued the following preliminary announcement:

The 50th annual meeting of the American Association for the Advancement of Science will be held in Denver, Colorado, August 24–31, 1901. The meetings of Section C will be held as heretofore in connection with the meetings of the American Chemical Society. The officers of the Section ask the cooperation of all the members in making the meeting a successful one. To this end you are personally requested to present one or more papers. Will you kindly fill out and return the enclosed blank giving us information as to whether you expect to attend the meeting; also the titles of any papers which you will present. According to the constitution, such abstracts of the contents of the papers as will give a general idea of their nature must be sent to the Secretary of the Section as early as possible. If you cannot present the abstract at this date, kindly send the title of the paper and furnish the abstract later. It is hoped to have reviews of the recent progress made in the various fields of chemistry. The presentation of such reviews by any of the members will be greatly appreciated. The officers of the Section will also appreciate any suggestions in reference to the program.

WILLIAM MCPHERSON,
Secretary of Section C.

OHIO STATE UNIVERSITY,
COLUMBUS, O.

THE American Microscopical Society will meet at Denver, in conjunction with the American Association for the Advancement of Science, on August 20, 30 and 31. The Secretary, Professor Henry B. Ward, of the University of Nebraska, promises that the meeting will be the best and most enjoyable yet held.

THE Council and Board of Directors of the American Chemical Society have authorized the expenditure of $500 for the publication in a separate volume of the proceedings of the twenty-fifth anniversary meeting of the Society, held last month.

IN addition to the civil service examinations that we have already announced for June 3d, there will be two others: that of secretary of the National Bureau of Standards, with a salary of $2,000, and that of field assistant in tree-planting in the Division of Forestry, with a salary of $1,000. On June 18th examinations will be held as follows: assistant ethnologist in the Bureau of Ethnology, at a salary of $1,200; zoological clerk in the Bureau of Animal Industry, at a salary of $840; a botanical clerk and assistant in the Department of Agriculture, at a salary of $1,000, and a special statistical compiler, Department of Agriculture, at a salary of $720. Those desiring further information concerning these positions should apply to the Civil Service Commission, Washington, D. C.

Two buildings for the Pacific Botanical Station, which is being established by the botanists

of the University of Minnesota, are in process of erection at a cost of about $2,500. The British Columbian Parliament has passed a grant for the construction of a road between the Port Renfrew dock and the Station site on the Straits of Juan de Fuca. A party of thirty or forty western botanists will leave Minneapolis under the direction of Professor Conway MacMillan and will spend the latter part of June and the first two or three weeks in July in the study of marine vegetation at the new seaside station, and of mountain vegetation at Banff, Alberta, and Field and Glacier, British Columbia. A subordinate party proposes to explore some of the little-known mountains of northern Vancouver.

WE learn from the *Botanical Gazette* that the valuable herbarium of the late Professor Agardh has been secured by the University of Lund.

MR. L. COCKAYNE, of Tarata, New Zealand, has recently presented to the New York Botanical Garden a large number of seeds of plants indigenous to the island, and has also donated nearly a hundred fine photographs, showing distinctive features of the vegetation of that island and also of Chatham Island, which he has explored within the last year.

THE collection of Indian relics and prehistoric anthropological specimens collected by Andrew E. Douglass has been presented to the American Museum of Natural History, New York. It contains about 23,000 specimens which were selected with great care.

THE collection of butterflies of the American Museum was opened to the public on May 24th. There are about 5,000 specimens, including the valuable collection given some time since to the Museum by the Rev. E. A. Hoffman.

THE library and collections of the late Dr. Jared P. Kirtland have been placed in the custody of Adelbert College by his granddaughter, Mrs. Caroline P. Cutter. Dr. Kirtland was a pioneer naturalist of the Western Reserve, the founder of the Kirtland Academy of Natural Science, and a man of wide attainments. His library contains about 2,200 volumes and embraces a wide field, including zoology, botany, geology, horticulture, travel, exploration, biography and local history. It is particularly rich in general and descriptive zoology of the mollusks, insects and fishes.

MR. SCHUYLER S. WHEELER presented to the Institute of Electrical Engineers, New York City, at its meeting on May 21st, the extensive and valuable library of electrical works collected by the late Latimer Clark, of London.

AT the monthly meeting of the Royal Meteorological Society on May 15th, Mr. W. Marriott gave an account of the bequest by the late Mr. G. J. Symons to the Society. By his will Mr. Symons bequeathed to the Society his Cross of the Legion of Honour, the Gold Albert medal awarded to him by the Society of Arts, the testimonial album presented to him in 1879 by the Fellows of the Royal Meteorological Society, and the sum of £200, as well as such of his books, pamphlets, maps and photographs of which there was no copy in the Society's library. Mr. Marriott stated that from Mr. Symons's valuable collection he had selected for the society over 5,000 books and pamphlets and about 900 photographs. A large number of the books were old and rare works, 750 bearing dates previous to 1800, while eight were as early as the 15th century. By this bequest the Royal Meteorological Society is said now to possess the most complete meteorological library in existence.

MR. CARNEGIE has given £100,000 for branch libraries for the city of Glasgow.

THE current issue of *Nature* contains the following further information and comments concerning the resignation of Professor J. W. Gregory from the leadership of the scientific staff of the antarctic expedition :

The great majority of scientific men in the country were confident that Professor Gregory possessed unique qualifications for the post of scientific leader of an expedition in which many branches of science required study and coordination. Under his direction, and with a competent naval head who should have an absolute veto upon all operations which involved risk to ship and crew, great scientific results were assured.

The opposition of the representatives of the Royal Geographical Society, which had obtained most of the funds voluntarily subscribed, and of a few scientific men belonging to the Navy, rendered it impossible that these full powers could be granted ; but a compromise acceptable to Professor Gregory was passed

by a large majority (16 to 6) of the Joint Antarctic Committee, including the officers of both societies and almost every expert on their joint lists.

The compromise provided, in the words submitted on February 12th to the joint committee, 'that a landing party, if possible, be placed on shore, under the charge of the director of the civilian scientific staff.' Professor Gregory was informed of this, accepted it, and the next day sailed for Melbourne.

The Royal Geographical Society's council refused to accept the compromise, and deputed three of their number to suggest to the officers of the Royal Society that the matter should be settled by a new committee of six, three to be appointed by each council. The Royal Society consented; the committee, chiefly composed of non-experts, met, and proposed modifications which Professor Gregory has been unable to accept.

We shall await with some interest to see whether the majority of Fellows of the Royal Society, and of other scientific men in this country, will approve the manner in which the Royal Society has acted as the guardian of scientific interests.

A CALL has been issued for the formation of an international botanical association, the first meeting of which will be held at Geneva on August 7th. One object of the association is the establishment of a bibliographic periodical, giving abstracts in English, German and French. An option for the purchase of the *Botanisches Centralblatt* has been secured. The Americans signing the call are Professor W. G. Farlow and Dr. David D. Fairchild, and the secretary is Dr. J. P. Lotsy, Wageningen, Holland.

THE eighty-fourth annual meeting of the Swiss Scientific Society will be held at Zofingen on the 4th, 5th and 6th of August. In conjunction with it, meetings are held of the Geological, Zoological, and Botanical Societies of Switzerland.

THE German Association for the Promotion of the Teaching of Mathematics and the Natural Sciences held its general meeting at Giessen from May 27th to 30th. The program included lectures on the teaching of physics and of geometry and on the use of text-books in the biological sciences.

THE second session of the New York State Entomological Field Station will be held at Ithaca during the summer months. Professor J. G. Needham, of Lake Forest University, will continue in charge of the work. The report of the first session, held at Saranac Inn last summer, is expected to be issued shortly.

THE Peary Arctic Club has chartered for this summer the steamer *Erik*, lately purchased from the Hudson Bay Company by Captain James A. Farquhar, of Halifax. It will sail from Sydney, C. B., about the middle of July, and will return, it is expected, about two months later, with full details of what has occurred during the two years since Mr. Peary has been heard from; also with information of the voyage of the *Windward*, in which Mrs. Peary and Miss Peary sailed from Sydney last year for the North.

IT is reported in the English papers that an American citizen has presented to the Pope a large telescope for the observatory in the Vatican. This observatory, under Father Denza, has carried on active researches since its reorganization in 1888.

A CABLEGRAM to the daily papers from Berlin states that during the past month experiments have been made between Berlin and Hamburg with the system of rapid telegraphy invented by the late Professor H. A. Rowland, of Baltimore, and it is said that the results are most satisfactory—the new system easily doing double the work done by the Baudot apparatus—and that the German Postal Department intends to introduce the Rowland system between Berlin, Hamburg, Cologne, Leipsic, and Frankfort. The system makes possible the transmission of eight messages simultaneously over a single wire, four in each direction, at the rate of forty words a minute.

WE learn from *Nature* that this year's Deutscher Geographentag opened at Breslau on Monday, May 27th. On the morning of May 28th Professor Neumayer proposed to present the report of a committee upon Antarctic exploration and to speak upon magnetic investigations in polar regions; Dr. E. Philippi on the 'Geological Problems of the German Antarctic Expedition,' and Professor A. Supan on the 'Antarctic Climate.' At the second sitting the subject to be discussed was the organization of geographical instruction, the speakers being Professor H. Wagner, Dr. Auler and Herr H. Fischer. On Wednesday morning, May 29th,

the subjects brought before the meeting related to the scientific study of lands and native races of German colonies. The speakers include Professor F. v. Richthofen, Professor G. Volkens, Dr. E. Kohlschütter, Professor K. Dove and Professor Schenck. The methods of geographical instruction were discussed in the afternoon of the same day by Mr. A. Becker, Professor A. Fischer, Professor A. Kirchhoff, Professor Langenbeck and Professor A. Bludau; demonstrations will also be planned by Professor K. Dove and Dr. M. Ebeling. In the evening an illustrated lecture was announced on glacier markings in Montenegro, by Professor K. Hassert, and one on the volcanoes of central France, by Dr. M. Friederichsen. At the fifth sitting, on May 30th, the papers dealt with various aspects of glaciers and glaciation, and the speakers included Professors Finsterwalder, H. Meyer, S. Günther, A. Penck, W. Goetz and Dr. W. Halbfass. On the afternoon of the same day, reports and papers were received from Professor A. Kirchhoff and C. M. Kan, and Dr. K. Sapper; and the general business of the association was transacted. Excursions have been arranged for a few days at the end of the meeting, and exhibits of geographical interest are on view in two museums in Breslau.

UNIVERSITY AND EDUCATIONAL NEWS.

THE Wisconsin Legislature has appropriated for the University of Wisconsin, at Madison, $210,000, in addition to the regular income previously derived from the State. Of this sum $150,000 is for a new building for the College of Agriculture, which is to house the administration offices of this department and the experiment station as well as the departments of bacteriology and chemistry. This College also receives $10,000 annual increase to its present income. The College of Engineering receives $30,000 for equipment of its new building which was provided by the last Legislature; also $7,500 annual increase in income. The newly organized School of Commerce secures $3,500 annual increase in its appropriations.

MR. EDWARD TUCK has given Dartmouth College $100,000 for a building for the Amos Tuck School of Administration and Finance. The College has also received a bequest of $10,000 from Mrs. Susan A. Brown as a library fund for the Department of Philosophy.

THE trustees of the John Carter Brown Library, acting under the provisions of the will of the late Mr. John Nicholas Brown, have decided to present the library with its $650,000 endowment to Brown University. This is the finest collection of Americana in existence. In addition to the books, whose value it is difficult to estimate, there will come to the university $150,000 for a library building and $500,000 of permanent endowment.

MR. ANDREW CARNEGIE has, as our readers doubtless know, offered to give £2,000,000 to the four Scottish Universities, Edinburgh, Glasgow, Aberdeen and St. Andrews, for the free education of Scottish students. He estimates that this income will pay the fees of all the students in the universities, including, we understand, the professional schools.

THE Council of Columbia University has resolved that all candidates for degrees at commencement shall be presented in English and that all degrees shall be conferred in English. Hitherto Latin has been used in part.

PROFESSOR R. W. WOOD, of the University of Wisconsin, has been appointed professor of physics in the Johns Hopkins University.

PROFESSOR H. B. LATHROP, who holds the chair of rhetoric at Stanford University, has resigned and has accepted the position of assistant professor of English in the University of Wisconsin.

ALBERT PRESCOTT MATHEWS, PH.D. (Columbia), has been elected assistant professor of physiological chemistry in the University of Chicago, and will be head of the department.

DR. O. M. STEWART, instructor in physics in Cornell University, has been appointed assistant professor of physics in the University of Missouri.

DR. E. SCHELLWEIN has been promoted to an assistant professorship of geology and paleontology at the University at Königsberg.